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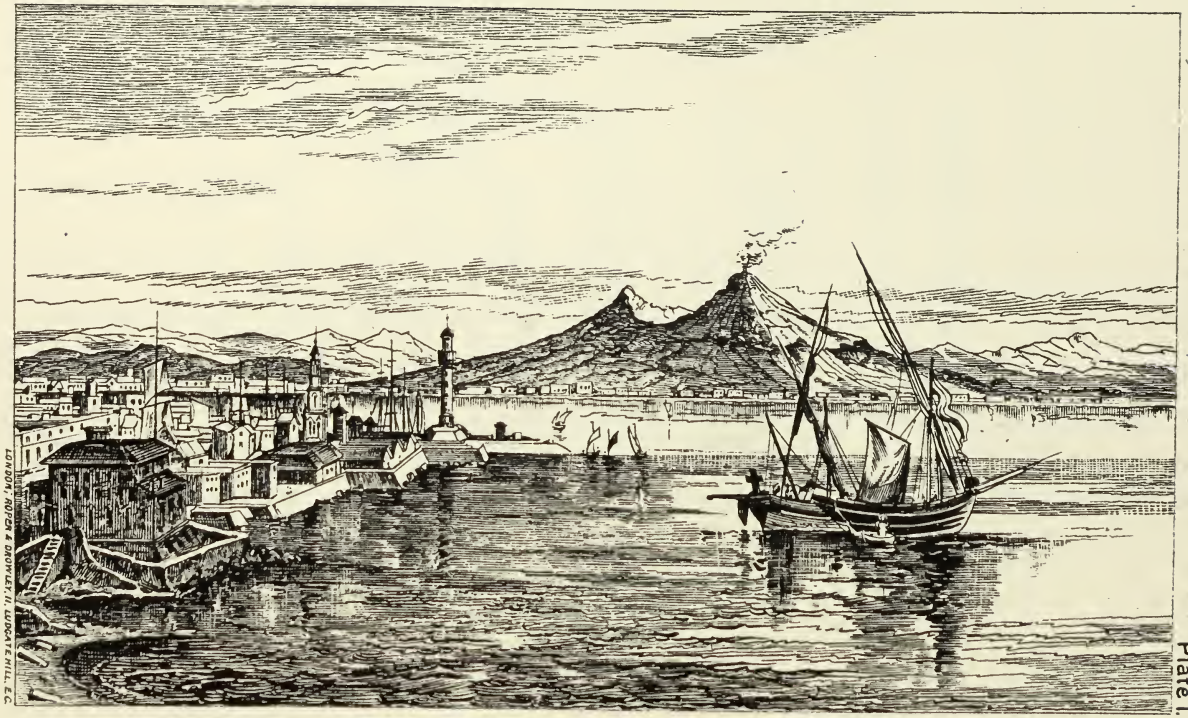

Plate I.

GENERAL VIEW OF MOUNT VESUVIUS FROM NAPLES.

MOUNT VESUVIUS.

A

DESCRIPTIVE, HISTORICAL, AND GEOLOGICAL ACCOUNT OF THE VOLCANO AND ITS SURROUNDINGS.

BY

J. LOGAN LOBLEY, F.G.S., &c.,

PROFESSOR OF PHYSIOGRAPHY AND ASTRONOMY, CITY OF LONDON COLLEGE;
AUTHOR OF "GEOLOGY FOR ALL," &c.

WITH MAPS AND ILLUSTRATIONS.

"Here verdant vines o'erspread Vesuvius' sides,
The generous grape here poured her purple tides."

"Now flaming embers spread dire waste around,
And gods regret that gods can thus confound."

London:
ROPER AND DROWLEY,
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1889.

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TO

THE FAITHFUL GUARDIAN

OF THE

HONOUR AND LIBERTIES OF ITALY,

AND

THE FRIEND OF SCIENCE AND EDUCATION,

HIS MAJESTY

KING HUMBERT I.,

THIS ACCOUNT

OF THE

GREATEST NATURAL WONDER

OF

THE ITALIAN PENINSULA

IS,

BY HIS MAJESTY'S VERY GRACIOUS PERMISSION,

MOST RESPECTFULLY DEDICATED.

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PREFACE.

SINCE "Mount Vesuvius" was published in 1868, much has been written on the subject of my brief sketch. A few months afterwards, at the beginning of 1869, Prof. John Phillips issued "Vesuvius," a work which, while rich in classic poetry and ancient fable, gave an extended account of the volcano and its surroundings, as well as a history in considerable detail of its eruptive activity to the end of the preceding year.

Since that time Prof. Palmieri, the faithful watchman of Vesuvius, has recorded the phenomena observable by the eye and ear, or appreciable by the seismograph, and has occasionally made public what appeared to him to be worthy of special attention. He has also written an account of the important eruption of 1872, of which an English translation has been published, with a lengthy and valuable "Introductory Sketch" by our late distinguished seismologist, Mr. Mallet. Descriptive letters in *Nature*, by Mr. Rodwell, containing much scientific information, have added considerably to our knowledge of the state of the volcano to the year 1880.

More recently there have appeared communications from an English resident in Naples, Dr. Johnston Lavis, who has devoted much time and labour to the study of Vesuvius, and who, as the secretary of the British Association Committee for the investigation of Vesuvian phenomena, has presented several reports on the subject; and an elaborate paper on the geology of the volcano, by the same gentleman, has been published in the *Quarterly Journal of the Geological Society*. In addition to thesesources of information and occasional letters and telegrams from Naples in the *Athenæum* and other journals, a very important volume has been published by the Italian Alpine Club, "Lo Spettatore

del Vesuvio e dei Campi Flegrei," in which is contained Prof. Palmieri's "Il Vesuvio e sua Storia," a new list of Vesuvian minerals by the eminent Neapolitan mineralogist, Prof. Archangelo Scacchi, and a record of changes and phenomena from 1882 to 1886, with photographs, by Dr. Johnston Lavis, together with much interesting matter by other authors. Recent excavations and well-borings have also added to our information respecting Mount Vesuvius, and hence a more complete account of the volcano can now be given than at any former period.

The present volume has therefore been prepared to give the latest knowledge on the subject, and to bring down the history of the mountain in a connected form through an interesting twenty years of its existence to the present time.

All the explanations of the causes of Volcanic Activity and its varied phenomena which have been advanced by previous Authors are admittedly so unsatisfactory, that I recently ventured to submit the new hypothesis given in the Chapter on Volcanic Action. In view of the great names associated with past attempts to solve the question, this Physio-Chemical theory is offered for consideration with great deference, and I trust that the attention given to the subject during more than twenty years may avert the charge of temerity.

Included in the Appendix are the four Contemporary Accounts of the formation of Monte Nuovo brought together for the first time; that by Simone Porzio not having before been published in English.

In addition to the writers on Vesuvius mentioned above, I am under great obligations to the other authors whose works have been consulted and whose names appear in the body of the work. The Chapter on the Flora of Vesuvius has been revised by Dr. Henry Wharton, M.A., F.Z.S., &c., to whom I am indebted for giving me the benefit of his extensive botanical knowledge.

The elevation of points on the mountain are taken from the great contour map of Vesuvius published by the Instituto Topografico Militaire of Italy in 1877, a magnificent map on the scale of 1 to 10,000, and for the convenience of general readers metres have been reduced to English feet. Translations have also been substituted for the original in classical quotations.

To make the book sufficiently complete, the original work has been recast and largely extended, and it is therefore hoped that the volume may prove not altogether unacceptable to the increasing number of Vesuvians as well as to ordinary visitors to the marvellously interesting and attractive Neapolitan volcano.

J. L. L.

City of London College,
August, 1889.

"Oh! land to mem'ry and to freedom dear,
Land of the melting lyre and conquering spear,
Land of the vine-clad hill, the fragrant grove,
Of arts and arms, of Genius and of Love,
Hear, fairest Italy."

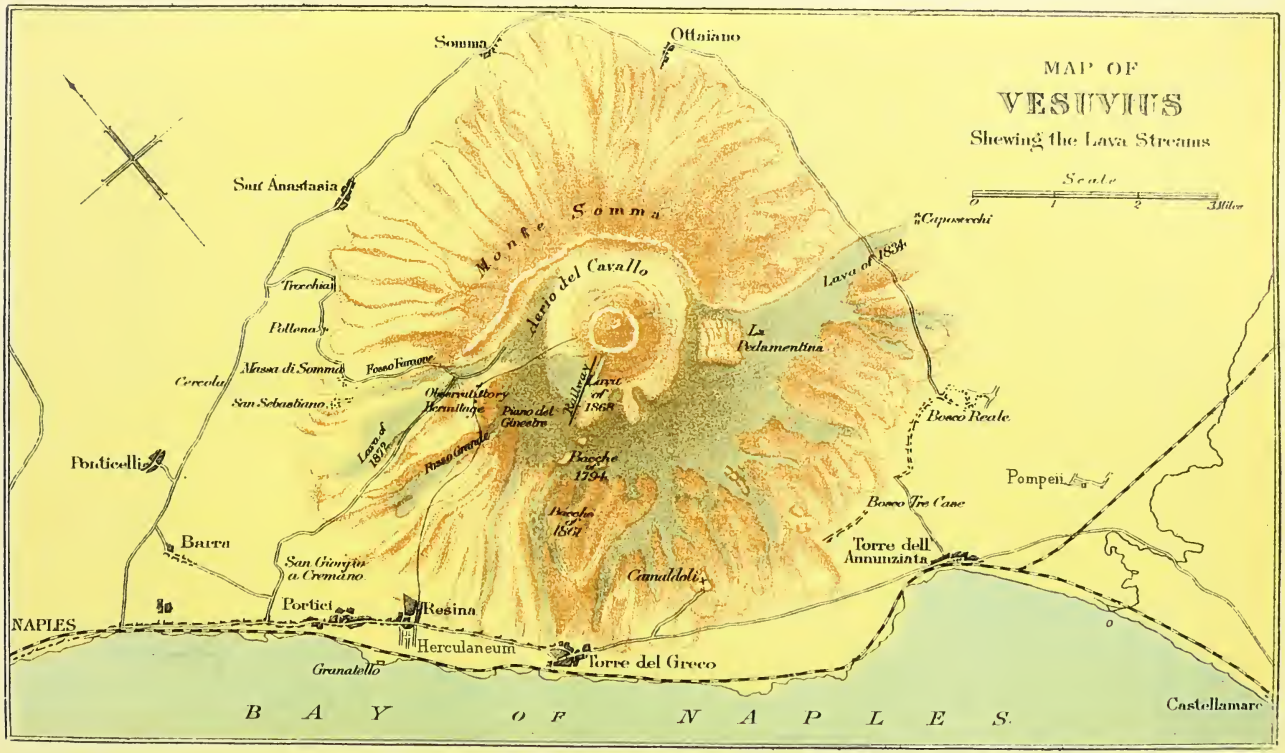
* * * *

"The leaves scarce rustled in the sighing breeze;
In azure dimples curled the sparkling seas,
And, as the golden tide of light they quaff'd,
Campania's sunny meads and vineyards laugh'd,
While gleam'd each lichen'd oak and giant pine,
On the far sides of swarthy Apennine."

* * * *

"Saw ye how wild, how red, how broad a light
Burst on the darkness of that mid-day night,
As fierce Vesuvius scatter'd o'er the vale
His drifted flames and sheets of burning hail,
Shook hell's wan lightnings from his blazing cone,
And gilded heaven with meteors not its own?"

MACAULAY'S "POMPEII."



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MOUNT VESUVIUS.

CHAPTER I.

THE NEAPOLITAN VOLCANIC REGION.

Three Principal Italian Volcanic Regions—The Neapolitan Volcanic Region—The Phlegræan Fields—The Solfatara—Extinct Craters—Monte Nuovo—Temple of Serapis—Tufa Hills—Stufe and Thermæ—Procida—Nisida—Ischia.

Mount Vesuvius, the world-famed volcano of Southern Italy, has been for many centuries an object of great interest to the inhabitants of Europe. In ancient times, the conspicuous position of the mountain in one of the fairest and most frequented portions of the Roman dominions — the resort of the most wealthy, most famous, and most noble of the citizens of Rome — and the terrible character and dreadful results of the eruption of the year 79, combined to render Vesuvius an object of especial interest and wonder. In modern times, the proximity of the volcano to one of the greatest cities of Europe, the accessibility to travellers, and the many attractions of the classic and romantic coast of Italy, with, especially, the frequency and violence of the eruptions, have

fixed the attention of mankind upon the Campanian fiery mountain not less earnestly than in the days of old.

But although Mount Vesuvius has absorbed so great an amount of attention, it must not be forgotten that it is but one of a large number of Italian volcanoes, active or extinct, and forms but the most prominent feature of one of the principal volcanic districts of Italy; for, besides the minor areas of the Euganian and Vicenian Hills, the Ponza Islands, the Rocca Monfina, and Monte Vulture, there are three principal Italian volcanic regions—the Roman, the Neapolitan, and the Sicilian, well marked and well separated from each other.

The most northern of the three, the Roman, occupies an extensive area between the Apennines and the Mediterranean, and although there is not now in Latium an active volcanic vent, there are very perfect examples of volcanic craters. Not twenty miles from the walls of Rome, the Lago Albano and the Monte Albano, the Lago Nemi, the Arco d'Aricia, and the great, though incomplete, crater-like wall of Monte Artemesia, at the southern side of the Roman Campagna, are well known; while north of Rome there are the Lago Bracciano, an immense crater-lake of twenty miles circumference, and the still larger Lago Bolsenna; while the "seven hills" of the Eternal City itself are but accumulations of ejectamenta from the volcanoes of the district.

In the southern volcanic region, the Sicilian, which is partly terrestrial and partly marine, the giant cone of Etna is still in full activity, and with Stromboli, the "lighthouse of the Mediterranean," never dormant, Vulcano and Vulcanello not far off, and the extinct craters of the other Lipari Islands, there are abundant evidences of great volcanic activity in the Sicilian Region, both at the present day and in long-past prehistoric times.

Intermediate between the Roman and the Sicilian regions is situated the Neapolitan volcanic region, which, like the Sicilian, is an area partly land and partly sea, since it comprises not only the Vesuvian mountain and the Phlegræan Fields, but also the marine area in which lie the volcanic islands of Ischia, Procida, and Nisida. It includes, therefore, all the Bay of Naples north of a line drawn from Ischia to Castellamare, for only on the south-eastern side of the bay from the last-named town to Capri are evidences of historic or prehistoric volcanic activity absent, though even here there are small deposits of tufa, but evidently not composed of material ejected from any vent on the Sorrento peninsula, a projection from the giant leg of Italy formed by a spur of the Apennines, and chiefly composed of the limestone called from those mountains the Apennine limestone.

The Neapolitan volcanic region is, like the Roman, and, indeed, like the Sicilian also, on the western side of the main mountain axis of Italy,

but unlike the former, though like the latter, it has still on one side a marine boundary. This fact has some significance on account of the continuing volcanic activity in the two regions which touch the sea, and the total extinction of the fires of that one which has been separated, though but a little distance, from the waters of the sea by the advance of the coast line.

But although throughout the entire district Mount Vesuvius commands most attention from its magnitude, its position, and the remarkable and splendid phenomena displayed during its frequently alarming and sometimes destructive activity, yet in some respects the area of the Phlegræan Fields is more remarkable still. The scene of classic fable and the theme of Roman poets, the land of gods and giants, titans and sibyls, the Campi Phlegræi excited the wonder and charmed the imagination of the ancient world. A land of fire, of smoke, of vaporous exhalations, mephitic and deadly, of deep hollows and cavernous recesses, of scorched rocks and stones, and subterranean passages, it well might be taken for the ruins of an older world, or imagined to be the vestibule of the realms of Pluto, with the inner portal at Avernus.

Yet, with all their terrors, the Campi Phlegræi were not wanting in charms and allurements for the luxurious epicures and sybarites of Rome, Neapolis, Baiæ, and Pompeii, for in the Lucrine

Lake were beds of the choicest oysters, and on fertile volcanic soils and sunny slopes were here produced the ancient banquet wines, and at but a little distance the famous Falernian itself. Here, too, were temples and baths, and looking over the beautiful Bay of Baiæ stood patrician villas, while towns and ports made busy the water's edge.

The Phlegræan Fields extend from Naples to the neighbourhood of the site of ancient Cumæ, with a breadth of six or seven miles, and, to accept the usually received etymology, were so named because of the fiery phenomena they displayed, from φλέγυρος, ardent or burning. Those, however, who love to find a Syriac origin for the names of places in a part of Italy early colonised by the Phœnicians, derive the word Phlegræan from the Syriac *Phele Gĕroh*, meaning "wonderful strife," an appropriate designation enough for a region that seems as if it had been a battle-field for beings having command of supernatural powers. Strabo, however, thought the neighbourhood was made the scene of the struggle of giants from its exceeding fertility giving rise to battles for its possession.

Certain it is it was very early colonised. Cumæ, its chief town—perhaps the most ancient of all Italian cities—flourished long before Rome was founded, and was the greatest centre of civilisation in Southern Italy in the days of the Tarquins, the last of whom died and was buried here. Its glories had even all departed in the imperial days of Rome,

for it was then spoken of as "Vacuæ Cumæ" and "Quieta Cumæ," and Juvenal says of it :—

> "Griev'd though I am an ancient friend to lose,
> I like the solitary seat he chose;
> In quiet Cumæ fixing his repose
> Where far from noisy Rome secure he lives,
> And one more citizen to Sibyl gives."
>
> *Dryden's Juvenal*, iii., 1.

It was afterwards fortified, and became the last stronghold of the Gothic Kings of Italy, but now nothing remains of this renowned city but a few ruins. Cumæ itself was situated upon a hill of volcanic material, a trachytic tufa, which breaks the monotony of the flat coast between Monte di Procida and the mouth of the Vulturno.

Between the region of volcanic craters and tufa hills and the Apennines lies the great plain of Capua, the *Campanus Ager*, all on volcanic material of abounding fertility, and famed also for its beauty and the goodness of its harbours, and one of the most valuable districts of Italy, constituting much of the province of Campania, which extends along the Tyrrhenian Sea from the Bay of Policastro to beyond Gaeta. In the time of Augustus, Campania was joined to Latium, and hence the neighbourhood of Rome is called by the modern term, Campagna di Roma.

So rich and fertile was Campania, and so easy and luxurious was the consequent mode of life there in the time of Hannibal, that his subsequent want of military success, resulting in the loss of Italy and the mastership of the world, has been attributed to

the enervating effect of a winter's sojourn on these volcanic soils. This affords a curious and remarkable illustration of the far-reaching consequences of the geological structure of a country.

It was by the Battle of Vesuvius, in 340 B.C., that this splendid district, the Campanus Ager, fell into the hands of the Romans. Then Puteoli and Neapolis grew and flourished, Baiæ and Pompeii rose, and Campania soon became the favourite place of retirement and residence for the distinguished and the wealthy of the dominating city on the Tiber. Great roads were constructed, and the Via Appia, the Via Latina, the road from Rome to Rhegium, and the Via Domitiana along the coast from Sinuessa to Neapolis, facilitated access to and through the beautiful region.*

The whole area of the Phlegræan Fields appears to be occupied by more or less completely ridge-encircled basins, one still evolving gases, hot fumes, and steam. Some of the wholly or partially circular hollows are enclosed by lofty walls of scoriæ and ashes forming incomplete or truncated conical hills, and a few are encircled by inconsiderable worn and wasted ridges at no great height above the sea-level, but all are evidently craters resulting from volcanic action. Looked down upon from above, the district would resemble most of all, to compare small things

* The chief towns of Campania were Capua, Cumæ, Neapolis, Nola, Baiæ, Pompeii, Puteoli, Herculaneum, Vulturnum, Liternum, Teanum, Salernum, Sinuessa, Misenum, Surrentum, Picentia, Venafrum.

with great, a portion of the surface of the moon, which, like that of the Phlegræan Fields, is doubtless also the result of past volcanic activity.

One of these craters is not yet indeed altogether extinct. The Solfatara, the "Forum of Vulcan," from a fumarole still gives forth volcanic fumes which deposit pure sulphur on the intercepting rocks and stones; and from it the name Solfatara is now generally applied to volcanic openings from whence issue sulphurous fumes. After speaking of Puteoli, Strabo writes: "Immediately above it is Vulcan's assembly-room, a level space surrounded by fiery heights, having numerous chimney-like mouths, which throw out smoke with great noise; and the level interior is full of drifted sulphur." Subterranean hollows furnish evidence of themselves by giving back resounding noises when heavy stones are thrown down upon the old crater floor, but so wide and level is the plain that its cavernous substructure seems to be due rather to fissures or interspaces between large masses than to a great abyss arched over by the present floor of the old crater. All around the low cliffs display degraded crater walls, but yet the Solfatara, as an active volcano, is by no means prehistoric, for there was an eruption here in A.D. 1198, when a stream of lava flowed to the sea and produced the great mass of trachytic rock forming Monte Olibano, Ὄρος Βάνος, the barren mountain, and covering the ancient cemetery on the Via Puteolana. This flow of lava was a very consider-

GULF
OF
GAETA
BAY OF
NAPLES
THE NEAPOLITAN
VOLCANIC REGION
Naples to Capri 19 Miles
Naples to Sorrento 19 Miles
STRAIT OF PROCIDA
I. PROCIDA
Procida
ISCHIA
I. CAPRI
Capri
NAPLES
Portici
Torre dell' Greco
Torre dell'Annunziata
POMPEII
SORRENTO
CASTELLAMMARE
Lava of 1760
Lava 1813
VESUVIUS
Nola
Marigliano
Somma
Ottajano
Striano
Pomigliano d'Arco
Anastasia
Barra
Trocchia
Palma
Licola
Foce del Fusaro
POZZUOLI
NISITA
Capo Miseno
Capo Minerva
C. di Sorrento
C. Sottile
Pt. of Syrens
Meta
Massa
Gragnano
Vico Equense
Plate III.
LONDON: ROPER & DROWLEY, 11, LUDGATE HILL, E.C.

able one, and touched the sea with a front of a quarter of a mile in width and seventy feet in height. The rock, essentially different from the lava rocks of Vesuvius, which are not trachytic, has been extensively quarried for building purposes. Dr. Daubeny says: "The trachytic lava of Monte Olibano, although differing from the rock of the Solfatara itself, agrees with it in being essentially a felspar with augite only occasionally." * The whole mass rests on a thick deposit of scoria and ashes. Previous to the eruption of 1198, which greatly injured Pozzuoli, the volcano appears to have been in very much the same condition as at present.

Between the Solfatara and the sea stood the city of Puteoli, which at one time almost extended to the volcano. Founded by a Greek colony from Cumæ, it was named Dicœarchia, but when in possession of the Romans it was by them called Puteoli, and became one of the two ports of Rome, the other being Ostia at the mouth of the Tiber. It was then the chief place of debarkation for travellers to Rome by sea from the south and from the east, from Egypt, Syria, and Greece, and was accordingly the landing-place of St. Paul, who remained at Puteoli seven days. So commodious was the harbour in the time of Augustus, both in space and depth, that the large vessels required for the shipment of the Egyptian obelisks then brought to Rome were well accommodated in its waters. The city has suffered

* Daubeny, "Volcanoes," p. 171 (1st ed.).

greatly by war, pestilence, earthquakes, and volcanoes, but under the name of Pozzuoli it is still a town of upwards of 15,000 inhabitants.

The Solfatara may be considered to be a connecting link between Vesuvius and the quite extinct craters of the Phlegræan Fields. Of these, Astroni is the largest, having an exterior circumference of about four miles, and a diameter of a mile, but it has so lost its volcanic aspect that it is now a royal preserve for "big game," wild boars and wild deer finding in the underwood of the arena of the amphitheatre, so to speak, a congenial covert and abode. The bottom of this large crater has in its centre a boss of trachytic rock without traces of a crateral opening, as if it had been pressed out of the volcanic tube in a plastic state and had remained a mound-like mass until entire solidification had followed. The circular hollow around is covered with oak and ilex, and beneath their shade are three secluded pools of water amidst rich verdure.

Monte Barbaro, anciently Mons Gaurus, is not so large a crater, though upwards of three miles in circuit, but it has much more lofty enclosing walls. It is a conspicuous object, displaying a high conical hill, with its steeply rising sides covered with vineyards. This is the highest of all the cratered cones of the Phlegræan Fields, and is geologically more than ordinarily interesting, on account of an opening through the crater wall on the eastern side which reveals its structure, and clearly shows that the whole

cone has been produced by the fallen fragmentary ejections from the central vent, probably the ejectamenta of one eruption only, without any flow of lava, no lava-rock being anywhere visible. In the immediate neighbourhood of Astroni and Monte Barbaro are two smaller but similar craters, named Monte Cigliano and Monte Campana.

Agnano, nearly three miles in circuit, is a crater much degraded, but holding until 1870 a lake of water, on the grassy banks of which frogs croaked and lizards crawled in great numbers. So worn and irregular are the boundaries of Agnano that it has not the appearance of a crater, but the beds of tufa dipping away from the interior leave no doubt that it is one, though probably much older than its more perfect neighbours. In consequence of unwholesome malarious vapours arising from the lake, though due not to volcanic fumes, but to the soaking of flax, drainage works were commenced in 1865, and completed in 1870, by the construction of a tunnel through Monte Spina, which formed a conduit for the waters of the lake to the sea. The area of the water surface was 924,020 square metres, and the depth of the lake 40 feet.* The effect of the drainage has doubtless had good sanitary and economic results, but it has removed a beautiful and interesting scenic feature.

Facilis decensus Averno is a familiar phrase to every schoolboy, but not only is the way to it pleasant and easy, but Avernus itself is pleasant

* Murray's Handbook to Southern Italy.

also. A circular lake of about a mile in circumference, surrounded by rocky shores adorned by luxuriant shrubs, and the glassy water reflecting its picturesque surroundings, it presents a by no means uninviting aspect. In early times, however, mephitic exhalations were doubtless given off from its sides, and the large trees which then overhung the lake that fills the old crater favouring the accumulation of such gaseous emanations, the traditions embodied by the classic poets in their verse would have some foundation.

"And here th' access a gloomy grove defends;
And here th' innavigable lake extends,
O'er whose unhappy waters, void of light,
No bird presumes to steer his airy flight;
Such deadly stenches from the depth arise,
And steaming sulphur, that infects the skies.
From hence the Grecian bards their legends make,
And give the name Avernus to the lake."*

But now the air is pure, and the aspect of the place cheerful, for there are no noxious gases and no dense overhanging woods to give a gloomy shade. Agrippa cut down the trees, and disregarding poets, traditions, and fables, constructed a "ship canal" from the sea to the lake, and thus Avernus was converted to practical purposes and made a secure harbour for Roman galleys. Some ruins of baths, or "thermæ," now called the Temple of Apollo, show that, notwithstanding its forbidding reputation, Avernus was resorted to in ancient times for health and pleasure.

* Dryden's "Æneid," book vi., 340.

The way is less easy to the "Cave of the Sibyl," which is far underground, with a chamber having some depth of water—the "Bath of the Sibyl"—so that a visitor is fain to be content to be carried on the shoulders of a guide. This is part of the old subterranean road from Avernus to the shores of Lucrinus, though containing what was reputed to be the entrance to the realms of Pluto.

"Deep was the cave, and downward as it went
From the wide mouth, a rocky, rough descent.
* * * * *
'Tis here, in different paths, the way divides
The right to Pluto's golden palace lies;
The left to that unhappy region tends
Which to the depth of Tartarus descends."*

On emerging from this gloomy cavern, with the placid water of Avernus reflecting the bright sunshine, and a gap in the seaward side of the old crater wall showing the Lucrine Lake and the blue sea beyond, even the most classically minded might well forget that he was near the Cimmerian abodes. Yet here were the reputed underground dwelling-places of those sunless beings whom Ulysses visited when on his famous travels.

"The gates of hell are open night and day;
Smooth the descent, and easy is the way;
But, to return, and view the cheerful skies—
In this the task and mighty labour lies."†

Exterior to the low broken walls of Avernus on the landward side is the partly encircling larger

* Dryden's "Æneid," book vi., 338 and 726. † *Ibid.*, 193.

crater of Monte Grillo, affording another instance of an exterior and an interior crater-ring which is so interesting a feature of the Neapolitan volcanic region.

On a level with the sea, and just outside Avernus, is the Lucrine Lake, and only separated from the bay of Baiæ by a mere causeway, fabled to have been first made by Hercules when driving the oxen of Geryon. It was raised and completed in a more prosaic manner by Agrippa. The canal from the sea to Avernus passed through Lucrinus, making a port with an outer and an inner harbour, and sufficiently spacious for the Roman fleet; but the cutting was filled up, together, doubtless, with a portion of the area of the lake itself, by the eruption of the adjacent Monte Nuovo in the year 1538.

And this is the remarkable crater near to the Lucrine Lake that is the newest of all in the Phlegræan Fields, for it is the creation of historic—nay, of modern times. Monte Nuovo is also close to the sea-shore, and, rising to a height of upwards of 400 feet as a truncated cone, displays a perfect though not quite circular crater, with steeply descending sides, nearly as deep as the interior walls are high. The height above sea-level of the summit rim is stated by Professor Phillips to be 440 feet, and the bottom of the interior crater only 19 feet above the same level, thus giving a depth of 421 feet. The greatest diameter of the crater is stated to be a quarter of a mile, but this must be a

mistake, as it cannot be nearly so much. The dimensions of Monte Nuovo are so differently stated that I greatly regret not having myself measured this remarkable hill. Dr. Daubeny says of it: "Monte Nuovo, 413 feet high, and 8,000 feet in circumference; composed entirely of fragments of scoriform matter, or of a compact rock of an ash-grey colour—no tufa." And Scrope: "Monte Nuovo, a tuff cone 430 feet high, with a crater 370 feet deep." While Murray states that "Internally the crater is a continuous cavity, free from fissures or dykes, about a quarter of a mile *in circumference*, 419 feet deep, and the difference between that and the height of the rim, 21 feet."

Monte Nuovo was produced by the volcanic energy of three days in September, 1538, which opened a new vent at this place on a plain, or "piano," not necessarily quite level, and, ejecting ashes and scoriæ, piled up the present hollow truncated cone, which appears to be composed entirely of ejected scoriæ and ashes, no lava flow or lava rock having been recorded or detected, though red-hot pumice is mentioned. Volcanic activity has not since recurred to alter its height or form, and thus the accumulation of ejectamenta with its regular crater remains very much as it was left by the creating eruption, except that it is now well grown over by the arbutus and other shrubs, both inside and out, though we are told that till the end of the last century the scoriæ was without vegetation.

From amidst the now peaceful and safe seclusion of the abundant covert so formed, an exceedingly fine fox was disturbed by my exploring footsteps. Monte Nuovo is, however, more than a mere interesting addition to the wonders around, since, as will be seen subsequently, it strikingly illustrates the method of the formation of volcanic cones generally, and possesses, therefore, great geological illustrative value.

The formation of Monte Nuovo was recorded by no less than four eye-witnesses—Marco Antonio delli Falconi, Pietro Giacomo di Toledo, Francesco di Nero, and Simone Porzio—whose accounts furnish an important chapter in the history of the Phlegræan Fields, as well as a most useful contribution to vulcanology. (See Appendix.)

Many earthquakes during the two preceding years presaged the eruption, and no less than twenty shocks were noted on the day of its commencement—the 28th of September. Condensed volumes of steam, with showers of ashes, produced deluges of mud that greatly injured the town of Pozzuoli, and it was afterwards found that the village of Tripergole, the Villa of Aggripina, and the canal of Agrippa had all been destroyed, while a rise of the coast was doubtless another result. Tripergole was a much-frequented watering-place for its mineral springs, with a hospital, and with three inns in the principal street.

But perhaps even more wonderful and significant

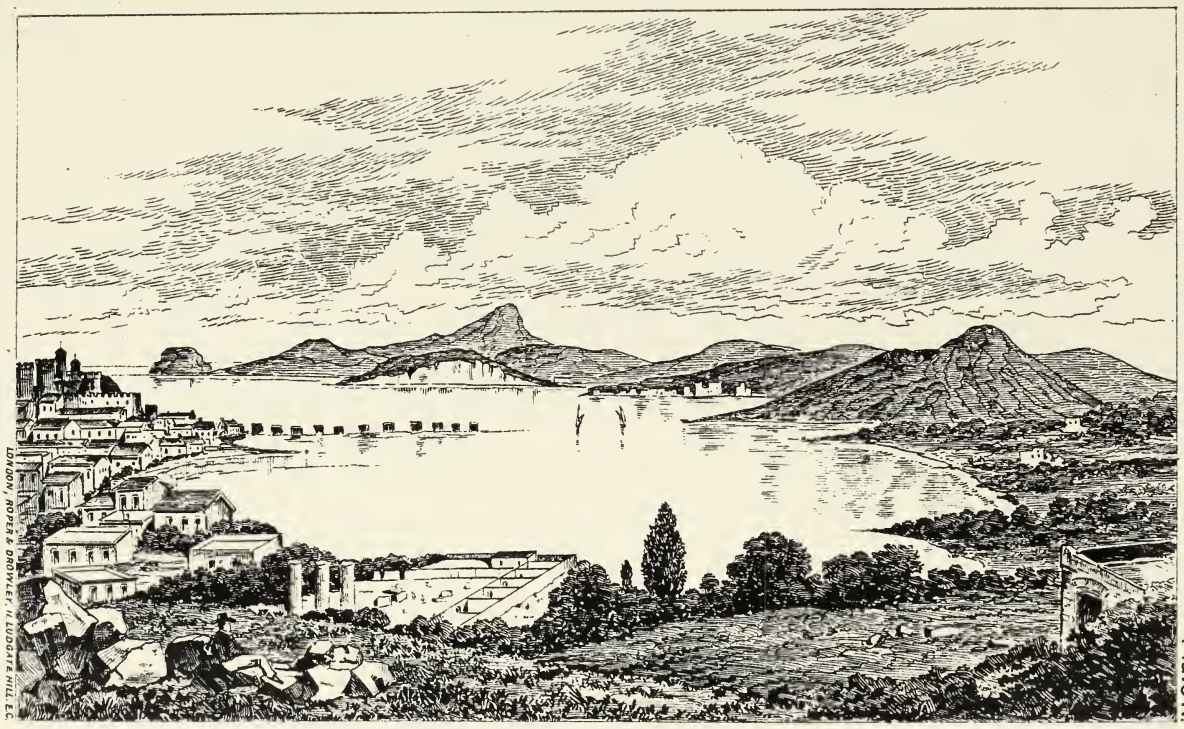

Plate IV.

VIEW OVER THE BAY OF BAIÆ FROM NEAR POZZUOLI.

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in the importance of their geological teaching are the remains of the ancient building usually called the Serapeum, or Temple of Serapis, but probably built for a sumptuous bathing establishment, near the western end of Pozzuoli, and close to the sea-shore. These remains consist of three Cipolino marble pillars, perfect in height, and although not connected by a superstructure, almost so in verticality of position, standing on a base about a foot below the level of the adjacent sea, the water of which percolates through an imperfectly protecting bank, and covers the ancient floor. At about twelve feet above the base, and occupying a zone of about nine feet in breadth, the same on each column, are the bore-holes of rock-boring marine mollusca (*Lithodomus lithophaga*), such as live abundantly in the adjoining sea, and now excavate their miniature tunnels in the rocks below the water-line. The existence of this zone of the perforations of marine animals would seem to at once conclusively prove that two changes of level to the extent of about twenty feet each had taken place, and as there is evidence of the interior of the temple having been decorated by marbles in the third century by Septimius Severus and Marcus Aurelius, that these changes of level had occurred since the commencement of the Christian Era. In other words, the site of the temple had, since the building was used in the third century, sunk to more than twenty feet, to which height the pillars had been submerged, and that subsequently a

reverse movement had taken place, and the ground had risen twenty feet, uplifting the pillars until their bases were nearly level with the surface of the sea. So it appeared to Breislac, but Dr. Daubeny, agreeing partly with Goethe and partly with the Canonico Jorio, thought that the lithodomi borings could best be explained by supposing an eruption of one of the neighbouring craters producing a mass of material that had impounded for a sufficient length of time a quantity of sea-water around the pillars when the sea had risen to an unusual height from seismic action. He considered that had two such great changes of level occurred as has been supposed, the pillars must have been thrown down.

Mr. Babbage, Professor James Forbes, and Sir Charles Lyell, however, have pointed out so many indications of change of level to the extent required, and even to thirty feet, in the immediate neighbourhood of Pozzuoli, both north and south, that no other conclusion than that there has been a subsidence and subsequent upheaval can now be come to. Dr. Daubeny's objection is replied to by the gradual and slow alteration of level alone required, and by the fact that buildings have actually descended from one level to another at the time of landslips without even injury to their walls. The three pillars of the Temple of Serapis therefore furnish most valuable evidence of the changes of relative level of sea and land that may occur, even in no very long periods of time, to entirely alter

geographical outline and terrestrial configuration.

Confirmatory of the above conclusion is the long stretch of low land by the sea-shore of the Bay of Baiæ, with a low cliff bounding it on its landward side, called La Starza. This is composed of horizontal beds of pumiceous tufa, containing not only recent sea-shells, but fragments of mosaic pavements, &c., all indicating a marine formation of historic times. The famous Mole of Pozzuoli, the so-called Bridge of Caligula, too, has some of its piers perforated by lithodomi ten feet above the sea-level.

The exemption of the lower portion of the three pillars of the Temple of Serapis from perforations is accounted for by the accumulation around them of the ejectamenta of the eruption of the Solfatara, in 1198, to the height of twelve feet, previous to the submergence which brought the sea-water to twenty-one feet above their bases. From this position they probably began to emerge before the eruption of Monte Nuovo in 1538, since in 1503 Ferdinand and Isabella granted to the city and university of Pozzuoli some land on the shore of the Bay of Baiæ where "the sea was drying," and in 1511 where "the sea was dried," and after 1538 newly discovered ruins were said to have been found on the shore near Pozzuoli. Previous to the formation of Monte Nuovo, the inner cliff between the Punta di Coraglio and the Lucrine Lake was the sea-cliff.

Since 1780 this part of the coast appears to have again subsided. Observations for sixteen years from 1822 were carefully made and recorded, and the result, as reported by Signor Nicolini, was that the land appeared to have been sinking during that period at the rate of about a quarter of an inch annually. Professor Guiscardi found, from noting the sea-line on the Mole of Pozzuoli, first in 1840, and then twenty-five years afterwards, in 1865, that a change of 0·349 metre had taken place, indicating a land subsidence at the rate of 1·396 metres in a century. This giving half an inch annually shows a doubling of the rate of subsidence.

The south-eastern boundary of the Phlegræan Fields is the commanding tufa-formed ridge of Posillipo (Παυσίλυπου, end of care), which separates this lunar-like district from the suburbs of the city of Naples, and overlooks the great bay towards Vesuvius, Sorento, and Capri. Through it runs the famous Grotto of Posillipo, an artificially formed tunnel for the high-road, of the construction of which there is no record. It has been ascribed to those busybodies of the olden times, the fairies, and also, with equal probability, to the magical power of Virgil, whose tomb is on the ridge near the eastern end of the grotto; but possibly it was cut by Marcus Agrippa, about the year 27 B.C.

Although the tunnel is a very considerable one, being no less than 2,244 feet long by 21 feet wide, with an entrance 69 feet high, diminishing to 25

feet, yet the rock is of so soft and easily worked a character that the labour of excavation would not be very great. Indeed, at the other end of the ridge, near the Punta di Coraglio, there is a still greater work of the same kind, forming a passage to the Villa of Lucullus. This tunnel, now called the Grotto of Sejanus, is nearly a mile in length, and was excavated by the engineer M. Coccineus, who was employed by Agrippa to cut the canal to Avernus.

The Ridge of Posillipo consists of the tufaceous rock that forms the whole of the area comprising the site of Naples and the hilly district on the north-west of the city. This rock, though varying somewhat in character, is essentially the same throughout, being a volcanic pumiceous agglomeration compacted together by having been deposited in the sea, as shown by its containing the shells of species of mollusca now living in the adjacent bay. In the neighbourhood it is quarried for cement, and has been used for that purpose since the days of the Romans, both Strabo and the architect Vitruvius having praised it for its still highly prized quality of cementing under water. It is widely known from the name of its place of shipment as "Pozzuolana."

Near Pianura, below the hill of the Camaldoli, the rock has a more granular structure, and is there quarried for building purposes under the name of Piperno. The Pianura itself, a circular plain within the larger sweep of the Piano de Quarto, is eminently

suggestive of a crater-floor. The highest point attained by the tufa hills of the district is at the Convent of the Camaldoli di Napoli, where the summit of the hill is 1,488 feet above the level of the sea, the highest eminence next Vesuvius in the district. As this tufa forms an area of many square miles, and is found to have a depth below sea-level of no less than 500 feet, while attaining so great a maximum elevation as that just stated, there is here the doubtless much-reduced presentation of an enormous aggregate amount of volcanic material, ejected long previously to the commencement of the present geographical conditions of this region. The fatal landslip at Santa Lucia in 1868 was caused by the soft character of the rock at that place, which had favoured the formation of the cracks and fissures by which the cliff behind the houses was shattered and a large mass of it thrown down.

From the concentric form of the two lines of elevations at the back of Naples, that of the Castle of St. Elmo and that of the Camaldoli, there is a suggestion of an outer and an inner crater ring. Breislac, indeed, was inclined to put the number of craters, of which there were indications in the neighbourhood of Naples, including of course those undoubted ones of the Phlegræan Fields, as high as twenty-seven, but the tufa, from its soft character, is so easily acted upon by erosive agencies that some may be hollows excavated out of a great thickness of the deposit.

As remnants of volcanic activity, or rather as evidences of still continuing volcanic heat, the stufæ and thermæ of the Phlegræan Fields deserve attention.

The chief seat of gaseous emanations, the Solfatara, has already been noticed. The fumes here evolved appear to be the same as were noted previous to the eruption of 1198, and consist of steam, sulphuretted hydrogen, and hydrochloric acid gas. Dr. Daubeny describes a very interesting series of chemical reactions resulting in the formation of sulphates and the deposition of sulphur, which latter is a conspicuous phenomenon at the Solfatara.

At the south-eastern side of Agnano, and before the drainage of the lake was commenced not far from the water's edge, the Stufe di Germano gives off vapours of sulphuretted hydrogen at 182° Fahr.

Not more than a few yards distant is the well-known and much-visited Grotto del Cane, where a poor dog is alternately half suffocated and revived for the gratification of tourists more curious than humane. The gas evolved at this place is carbonic acid, produced by the decomposition of calcareous rocks below, and this, from its greater specific gravity than air, accumulates near the floor of the grotto, and so forms, as it were, an anti-vital and an anti-combustion bath. Dr. Daubeny says: "I found that phosphorus would continue lighted at about two feet from the bottom, whilst a sulphur match

went out a few inches above. It was impossible to fire a pistol at the bottom of the cavern." *

Near to the Lucrine Lake the Stufe de Nerone with hot vapours and a spring in the interior of a temperature, according to Prof. James Forbes who penetrated to the extremity of the cavern, of 182·5° Fahr., and "sufficiently hot to boil an egg in a very few minutes." † Dr. Daubeny attempted to follow the example of Prof. Forbes, but was driven back by a sense of suffocation before he had reached half-way to the end stated to be at 120 paces from the entrance. This stufe is still resorted to for curative purposes as it was in the days of Nero, when Martial wrote :—

"Quid Nerone pejus?
Quid thermis melius Neronianis?"

The amount of volcanic vapour evolved in this region, however, appears to be less than of old, for, to say nothing of the reputed mephitic vapours of Avernus, volcanic gases seem to have been emitted from the island of Nisida in the first century of our era, since Lucan writes :—

"Thence deadly plagues invade the lazy air,
Reek to the clouds, and hang malignant there,
From Nesis such, the Stygian vapours rise,
And with contagion taint the purer skies."
Rowe's Lucan, "Phars.," vi., 141.

But so recently as 1838 fumes issued from the Lake of Fusaro, destroying, it is said, the oysters that took the place of those of the Lucrine Lake.

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* Daubeny, "Volcanoes," p. 199. † *Ibid.*, p. 210.

The hot springs, or Thermæ, are numerous, but the repute and greatness of Baiæ, and indeed the words of Pliny, would seem to indicate that they were more copious, as well as more medicinally powerful in ancient than in modern times. Pliny writes: "Nowhere do mineral waters abound in greater number or offer a greater variety of medicinal properties than in the Gulf of Baiæ, some being impregnated with sulphur, some with alum, some with salt, some with nitre, and some with bitumen; while others are a mixture of qualities, partly acid and partly salt. The springs at Baiæ, now known as Posidian, after the name of a freedman of the Emperor Claudius, had waters so hot as even to cook articles of food" (Pliny, xxxi., 2).

From the exterior of the bounding ridge of the Solfatara, at a part called Monte Sicco, in the hollow between it and Agnano, the aluminous spring of Pisciarelli, called by Pliny the Fontes Leucogæi, gushes out at a temperature of 180° Fahr.

At Bagnoli, on the sea-shore between the Capo di Posillipo and Pozzuoli, are two mineral springs that still furnish hot water at a temperature of 104° to a bathing establishment in daily use. The water at one place contains salts and carbonic acid gas, and at another sulphur and iron.

On the west of Pozzuoli, at the Serapeum, that monument of Art but silent witness of Nature, there are still the warm springs that were the cause of

the erection of what some antiquaries consider were baths; for even if the edifice was really a temple of Jupiter Serapis, its site was doubtless determined by the medicinal springs, since that Egyptian deity included amongst his attributes those of Esculapeus.

The warm springs of Avernus were, too, of sufficient importance to occasion the erection of the baths now named the Temple of Apollo, in one of the chambers of which there is still a mineral spring, the Acqa Capona, and a little distance beyond the Lucrine Lake there are the Bagni di Tritoli.

The baths of Bauli are the modern representatives of those thermæ, the Myrtetæ, that made Baiæ, to use a term of to-day, the greatest "watering-place" of the ancient world. Both previous to and all through the Imperial era there was at this, the most flourishing pleasure resort of Italy, concentrated much of the wealth and luxury, the refinement and the dissipation of Roman civilisation. Horace says: "Nullus in orbe sinus Baiis prælucet amœnis"* (Hor. Ep., b. i., 83); and Statius writes:—

> "Fair Baiæ's shores, for tepid springs renowned,
> Where all the gay delights of life are found."
> Statius, Sil., III., v. 95.

To Baiæ and its neighbourhood came and abode in elegant villas and splendid palaces Caius Marius, Lucullus, Pompey, Julius Cæsar, Nero, Caligula, Hadrian, Severus, and Tiberias, as well as Horace,

* Nothing in the world can outshine the lovely Bay of Baiæ.

Cicero, Virgil, Pliny, and, indeed, all the greatest of the Roman world.

"Land of Venus, golden coast,
Nature's fairest gift and boast,
Happy Baiæ!"

Martial, xi., 80.

Thus Baiæ flourished till the terrible fifth century brought the destroying power of Theodoric the Goth.

The tufaceous ground forming the site of the city of Naples, and connecting the Vesuvian with the Phlegræan area, establishes the continuity of the volcanic character of the whole district from Pompeii to Cumæ. Eastwards the whole plain is on the same volcanic tufa, and westwards the region is extended by the promontory of Misenum and the islands of Procida and Ischia.

No one can doubt the volcanic origin of the bold headland of Misenum who sails past it and sees its almost vertical cliffs showing concave indentations that are obviously the remains of craters, and a close inspection will show them to be composed of volcanic materials. Behind lies the crater-like Porto Miseno and the Mare Morto, the former of which was the chief station of the Roman fleet, while beyond extends the Elyssian Fields and the Palus Acherusa, now the Lago Fusaro, lying between Avernus and the shore of the Gulf of Gaeta.

Volcanic structure is conspicuously displayed in the cliffs of Procida, and the alternate beds of tufa

and lava can be plainly seen from any passing steamer. At one part of the natural section exposed the beds are conspicuously arched, and this has been cited in support of the "*Erhebungs Cratere*," or "craters of elevation" theory of Von Buch. There seems to have been a tradition of volcanic activity in this island, for in Strabo's time a legend was current of Prochyta (Procida) having been torn away from Pithecusa (Ischia). Procida is two and a half miles long only, but has 13,000 inhabitants, and is richly cultivated.

The crescent-shaped isle of Nisida, the Nesis of the Romans, is, too, conspicuously volcanic, the little island being but the landward, less exposed, and consequently remaining part of a crater.

Ischia (anciently named Pithecusa, Inarime, and Œnaria), under which the Typhon was said to lie and groan, and occasionally move under his heavy coverings, a fable obviously founded on the volcanic character and traditions of the island, is much larger than Procida, being nearly twenty miles in circumference (length, seven miles; breadth, four miles in the narrowest part), and though volcanic too, is formed of different materials, the prevailing rock being a fine-grained tufa, a re-agglutinated comminuted pumice, while its lavas are trachytic. Towering above the whole island is the central cone of Epomeo, or San Nicolo, the *Epompeus* of the Romans, with an elevation of 2,605 feet above the level of the sea. This mountain, although

entirely volcanic, is, like the Puy de Dome of Auvergne and other trachytic cones, without a summit crater, the volcanic mouths being on its sides. An eruption of importance, and the last to the present time, took place here in 1302, when lava was emitted from a mouth on the lower slopes of Epomeo, called the Cremate, which reached the sea and formed the Lava d'Arso. Earthquakes and eruptions before the Christian era repeatedly drove out the inhabitants, who had, as colonists, successively settled on the island, first the Erythræans, then Chalcidians, and afterwards colonists from Syracuse. No less than twelve volcanic cones on this small island form enduring memorials of previous great volcanic activity; but the fiery forces under Ischia have not been altogether desolating in their consequences, since the volcanic products have formed a soil so fertile that shrubs grow beyond their normal size, and the vines are remarkable for their luxuriance. The most noteworthy of the cones around Epomeo are Monte Rotaro, Montagnone Monte Tabore, Monte Corvo, Monte Vico, and Monte Campignano.

The whole island is evidently volcanic, and the destructive earthquakes of 1881 and of three years ago are indications that Ischia is still inside the area of seismic, if not of volcanic disturbance. Indeed, the earthquakes at Casamicciola have been regarded as ominous warnings of a coming renewal of the volcanic activity of Epomeo, since they have

been likened to those that injured Pompeii sixteen years before the renewal of the long-dormant activity of Vesuvius. But these fears may well be allayed, if not put on one side, when it is remembered that not far distant there is the now frequently and freely opened vent of Vesuvius that may possibly be sufficient to relieve all pent-up volcanic force beneath this area. Let us hope this may be so, and that the fires of Vulcan may serve but to heat as now the water of the hot baths of Gurgitello for the benefit of the Neapolitan and other visitors to the beautiful island, who may thus be able to continue to enjoy undisturbed the fresh Mediterranean breezes, the splendid position, and the charming scenery of this gem set in the azure sea.

CHAPTER II.

THE SURROUNDINGS OF VESUVIUS.

Characteristics—Populousness — Naples — Destroyed Towns — Ring of Towns—Bay of Naples—Appearance from Naples—View of Surroundings from the Mountain.

The chief characteristics of the immediate environment of Vesuvius are fertility and populousness, for the country all around is most productive, and, apart from Naples, the whole base of the mountain is skirted by a series of villages and towns, some of which have a large number of inhabitants, especially those on the shore of the bay, where, although the eruptions of past times have frequently covered the ground with lava, and destroyed the habitations of man, there is a great population living, apparently, without any dread of the dangerous neighbour whose threatening thunders they so often hear.

Nor is this great accumulation of humanity in the favoured and fertile yet threatened and sometimes devastated Campania di Napoli a merely recent one, for Strabo speaks of the glorious Bay of Naples, which he calls the "Crater," between "the two promontories Misenum and Athenæum, which look towards the south, enriched everywhere with the before-named cities, with villas, and with cultivation so closely adjacent as to appear like one continuous city."

It is estimated that there are now upwards of 80,000 inhabitants on the slopes and skirts of Vesuvius, and that had no volcano arisen here, the country would not have supported more than a tenth of its present population. The destruction caused from time to time by eruptions is therefore amply compensated for by the abounding fertility of the soils resulting from the decomposition of volcanic products, which give the means of subsistence to a vastly increased number of inhabitants.

The populousness of the immediate vicinity of Vesuvius is emphasised in the neighbouring great city of Naples, the most densely populated city of Europe, containing about half a million of inhabitants crowded on to an area of little more than four square miles. The streets of Naples derive dignity rather from the loftiness of the houses than from the width of the roadway; for, with few exceptions, they are, especially in the eastern half of the town, narrow lanes between habitations of six and seven storeys high, without kerbs or side-walks, but well and most enduringly paved with hard lava-rock. Yet the few exceptions, as the old Strada di Toledo, now the Via di Roma, and the Riviera di Chiaja, are noble roads with good side-walks. Neither are there large open spaces or gardens amidst this dense mass of human habitations, the chief public gardens, the Villa Nazionale and the Giardino del Populo, being situated on the shore of the bay.

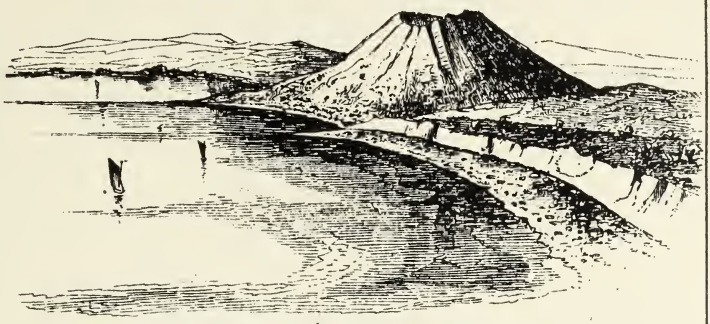

FIG. 1. MONTE NUOVO FROM POZZUOLI

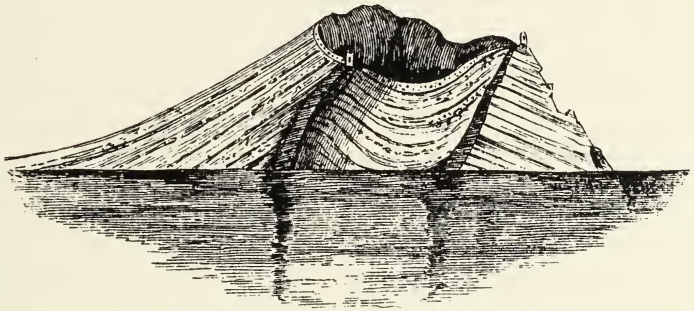

FIG. 2. PROMONTORY OF MISENUM

FIG. 3 THE PHLEGRÆAN FIELDS.

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The volcanic structure of the site has produced two roughly semi-circular depressions opening to the sea, and divided from each other by a tufa ridge extending inland from opposite the islet of the Castel dell' Ovo, the Isola del Salvatore (the Megaris of Pliny), at Pizzofalcone, above Santa Lucia, to the elevation on which stands the Castel St. Elmo, where it joins the bounding ridge of the two depressions.

Like Puteoli, the original city was founded by a colony of Greeks from Cumæ, and named Parthenope, after the siren, whose tomb was shown in the time of Strabo. A second party of Greek colonists, it is said, from Chalcis and Atica, formed another but adjoining settlement, which was accordingly the new city, and the first settlement became the old town, or Palæopolis, and so they remained until both fell into the hands of the Romans, under Publius Philo, in B.C. 328, when they became united or merged, and the name Palæopolis disappeared, the designation Neapolis, or new town, being used for the combined city during the whole of the Roman period, and giving the modern Italian Napoli, and our word Naples.

Neapolis was a favourite place of residence with some of the Roman emperors. Titus was Archon, and Hadrian was Demarch of the city, while on the neighbouring hill of Pausilypus (Posillipo) Virgil composed his "Georgics," and at Neapolis Nero made his first appearance on the stage.

Horace calls it "otiosa Neapolis," Martial "docta Parthenope," and Ovid says, "in otia natum Parthenopem." The city suffered greatly during the Gothic wars. It was taken in 536 by Belisarius, and in 542 by Totila, after which it became for a long time a dependency of the Exarchate of Ravenna. After many vicissitudes it was, with its territory, united with Sicily in the kingdom of the Two Sicilies, until in 1860 Garibaldi freed it from the Bourbons, when Naples became the chief city of a Province of the Kingdom of Italy, since which time much of the picturesque idleness has given place to more prosaic industry, which has transformed many of the famous lazaroni into dock-labourers.

Though Naples has never suffered devastation from the eruptive activity of Mount Vesuvius, its inhabitants have at intervals been thrown into the greatest terror by the more violent outbursts, and Vesuvian ashes have frequently darkened the city. The immunity enjoyed by Naples from serious injury was ascribed to the protection of San Januarius, its patron saint, in recognition of whose favour in having saved the city from famine, war, plague, and the fire of Vesuvius, the Cappella del Tesoro at the Cathedral was built, between 1608 and 1637. The Museo Nationale, containing the recovered artistic and antiquarian treasures of Pompeii and Herculaneum; the University Museum, with its great collection of Vesuvian minerals, under the

care of the venerable Professor Archangelo Scacchi, and the Club Alpino, with a library of, it is stated, 25,000 works on Vesuvius, vulcanology, and seismology, all additionally associate Naples with Vesuvius.

The re-awakening of the long-dormant forces of the volcano in the first century of the Christian Era was a terrible one for the then inhabitants of the cities and towns at the base, for four or five were entirely destroyed, though even then it is probable that not a large number of the population perished.

About six miles from the summit, and on the south-eastern side of the mountain, are situated the half-uncovered ruins of Pompeii, the chief victim of the destructive powers of Vesuvius. At the base of the mountain, near the shore of the bay, and partly under the modern town of Resina, Herculaneum lies buried, while the ruins of Stabiæ, the third of the cities destroyed by the eruption of A.D. 79, are close to Castellamare, at a distance of eight or nine miles from the crater of the devastating volcano, and at the commencement of the peninsula of Sorrento, which, here forming a right angle in the shore line, extends westwards as the southern side of the bay. In addition to these, but not usually mentioned as victims of the devastating eruption of 79, it seems to me probable that Retina, at the water's edge, the harbour of which Pliny states was blocked by fallen ashes, and the Post Station of Oplontum, to the south-east of Hercu-

laneum, were also destroyed by the Plinian eruption.

The mountain is completely encircled by a road running round its wide-spreading base, and connecting the many villages and towns at its foot into one long series of human habitations that has few parallels. This road is upwards of twenty miles in length, and commencing as it does near Naples, and running along the shore of the bay, and then continuing round the mountain on the inland side, some of the places through which it passes are suburban, while some have a seaside, and others, though populous, have surroundings of a quite rural aspect and character.

They all agree, however, in having the great mountain towering above them on one side; they are all within hearing of its rumblings and bellowings, and all can see its summit fires and ascending smoke, but they are not all equally liable to injury or devastation from its eruptive energy. The strong and massive bulwark of Monte Somma, extending for two miles outside of the eruptive cone, effectually protects a large area on the north-eastern side of Vesuvius from lava streams, but still much destruction may be caused to growing crops and fruit-trees, and even to towns, as was the case with Pompeii, by heavy falls of ashes even on this side, for from these Somma is no protection.

Though the road round Vesuvius is a populous and animated one, that between Naples and Resina

is still more so. This road of about five miles, passing as it does through the manufacturing and shipping, and therefore the densest part of the Neapolitan capital, and the little less dense adjacent suburbs, is a most busy and noisy thoroughfare, abounding with scenes and objects calculated to arrest the attention of the lover of the picturesque, as well as the observation of the student of national characteristics. Soldiers, sailors, ecclesiastics, fishermen, lazzaroni, and beggars attract the eye by their varied and un-English-looking costumes, and carrozzelle with their picturesque groups of riders, fourteen or fifteen on one vehicle, of all ages—soldiers, sailors, priests, women, children—and with nimble, fast-trotting little horses rattling along over the hard lava-paved road, add great animation to an already lively scene, crowded as it is with figures and surrounded by varied and broken outlines, bright with colour, and lighted by brilliant sunshine. Sounds as well as sights are many, and cheerful too, at this east end of Naples. The rattle of carriages over the stony street, the crack of whips, the jingle of harness-bells, and the calls of drivers, mingle with the music of a military band or the sound of church bells, while the song of the street minstrel, and, perchance, the squeak of Punchinello, give further local tone.

On leaving the Piazza del Plebiscito in front of the Palazzo Reale, the frowning towers and battle-

ments of the grim old castle of Charles of Anjou, the Castel Nuovo, is first passed, and then the two commercial harbours of Naples, the Porto Grande and the Porto Nuovo, with their shipping and sailors, extend for a long distance between the road and the sea, into which project the moles or breakwaters that form the harbours, with the new Giardino del Popolo at the water's edge.

Further along the Marinella stands the Castel del Carmine of Ferdinand I., the rendezvous and stronghold of the populace in Masaniello's insurrection, and subsequently a political prison, and still further barracks that were built for a public granary called I Granili. The little river Sebeto, which drains the low lands at the west of the mountain, is crossed by the Ponte della Maddalena ; and, lined with houses of all sorts, churches, maccaroni and other manufactories, the road, now fairly out of Naples, passes through the village of San Giovanni a Teduccio, adjoining the little town of La Barra ; and the town of Portici then continues the urban character of the road the whole distance to Resina.

The name Portici is a memorial of the buried city of Herculaneum, since it is taken from this place being the Porticum Herculis, or approach to the great temple of Hercules, to whom the city was dedicated, and stated by Petronius to have been at the west end of Herculaneum. Portici, with a population of nearly 12,000, has a Royal Palace, built by Charles III. in 1738, on a bed of lava rock, the

produce of the great Vesuvian eruption of 1631, and on this lava are the beautiful gardens attached to the palace. This great bed of lava covers the tufa in which the ruins of Herculaneum are embedded at a depth of 70 or 80 feet below the present surface of the ground. At one time the palace was a place of great interest, since in it were displayed the portable antiquities taken from the ruins of Pompeii and Herculaneum, but now all these objects have been removed to the Museum at Naples. There are also at Portici a barracks, a Francescan monastery, and at the water-side the castle or fort of Granatello, from which a fine view of the bay can be obtained. A great bed of lava, 38 feet thick and 700 feet wide, is here cut through for the railway. All this neighbourhood, with Portici, St. Giorgio, and Barra, is a favourite locality with the Neapolitans for residences.

Resina, with a larger population than Portici, nearly 14,000, is like it a favourite place of residence for wealthy Neapolitans. This town stands partly over the ruins of Herculaneum, an entrance to which is in the main street. Resina is the modern representative of the ancient Retina, which must have been a small place at the water's edge. It was to Retina that Pliny the Elder, during the eruption of 79, set out from Misenum by sea to go in order to rescue the Roman garrison from danger, but finding the harbour so filled up with the fallen Vesuvian ashes that he was not able to communicate with the place, he went on to Stabiæ, where he died. As

Resina is the town from which the ascent of Vesuvius is usually made, it is the chief abode of the Vesuvian guides that so beset visitors to the mountain. It is common to hear these very useful, though perhaps too pertinacious, men spoken of disparagingly, but my experiences of them were altogether satisfactory. On one occasion, great faithfulness and courage were displayed at a time when I might safely have been deserted and left in considerable danger. Of the villas of the neighbourhood, the largest and most interesting is that of the late Prince of Salerno, called La Favorita, which contains a mosaic found in the Palace of Tiberias at Capri. Like the Palace at Portici, La Favorita is built on the lava of 1631.

About a mile further along the road, and seven and a half miles from Naples, is the still larger lava-built town of Torre del Greco, which has a population of between 23,000 and 24,000, and enjoys a very considerable amount of commercial prosperity, notwithstanding the many and terrible injuries it has suffered from eruptions. This port is the seat of the Mediterranean coral fishery, which is such an important industry that no less than 200 vessels belonging to Torre del Greco are employed in it. The area of the fishery is so large as to include the waters of Corsica and Sardinia. Besides the coral trade, there is a great production of wine and fruit from the gardens adjacent, all on the decomposed lavas of the lower slopes of the mountain. The fruit

grown here is exceedingly fine in quality, and abundant in quantity, especially the grape, from which very choice wines are made. Of these, the most famous is the celebrated Lachrymæ Christi, which is sold cheaply at the gates of the vineyards where it is produced. There are many good country houses in the vicinity, and in the town a handsome collegiate church, three convents, and a large hospital.

Torre del Greco has suffered from the eruptions of Vesuvius more than any other existing town, since it has been repeatedly devastated by lava streams, which have flowed through the place to the sea. But these lava-flows have afterwards become the rocky foundations for new buildings, so that the town has stood on several levels. The eruptions of 1631, 1737, 1794, 1822, and 1861 were especially destructive, and an earthquake in 1857 also occasioned great damage. A writer in the *Athenæum* states that after the eruption of 1861, during the earthquakes preceding which fissures were opened in the streets, he descended from the surface, and found himself in a church below that had been covered by the products of a previous eruption. The most destructive of all the eruptions was that of 1631, which, by the floods of lava that poured through Torre del Greco, completely destroyed two-thirds of the older town, and it is on this lava that the present town chiefly stands. The readiness of the inhabitants of this town to rebuild after every

destructive eruption has given rise to the Neapolitan saying, "Napoli fa i peccati, e la Torre li paga."* Still further to the south-east the remains of the Roman post station Oplontum can be seen. It is, like Pompeii, buried beneath lapilli, and now not more than the remains of a few houses, with their intervening lanes, can be distinguished.

The shore-line here, as far as Torre del Annunziata, has been greatly affected by the lava-flows of past eruptions, especially by those of the terrible outburst of 1631, which, advancing to the shore of the bay, entered the sea at several points, and formed promontories of compact lava-rock. These masses are cut through by the railway along the coast, running between the high-road and the sea, and they may be well seen at several points. One branch of the great flow is quarried at Torre Scassata, a little way from Torre del Greco, on the shore of the bay, where has been developed the beginnings of that remarkable columnar structure which is such a marked characteristic of basalt. At a place near here a recent excavation for a new building cut quite through a bed of this lava, enabled me to procure some of the lapilli on which it rested, and which was of a dull brick-red colour, much more resembling that of some of the tufa of Rome, the *Tufa lithoide*, than the lapilli of the neighbouring Pompeii.

* Naples commits the sins, and Torre pays for them.

Standing on a considerable elevation at some distance on the left, well up on the side of the mountain, and not far from the "bocche," or eruption mouths of 1861, is seen the Convent of the Camaldoli della Torre, surrounded by a grove of luxuriant oaks. Often threatened with destruction, the convent has as often been protected from the fiery lava by the eminence on which it stands, which has repeatedly divided or diverted the flows descending this side of the mountain.

Beyond Torre del Greco there is a stretch of low, flat land, part of the pre-Vesuvian Campanian plain, between the receding outline of the base of the mountain and the sea, and over this the road runs to the large fishing town of Torre del Annunziata, on an indentation of the coast-line. This town, with a population of about 16,000, is twelve-and-a-half miles from Naples, and the railway from that city, which has kept close to the shore the whole distance, now bifurcates—one branch, inclining inland, passes Pompeii, and the other continues along the coast to Castellamare. Torre del Annunziata is a walled town, and is further defended by a tower which gives the place rank as a fortress. It has several industries besides fishing, such as milling and the manufacture of fire-arms, gunpowder, paper, and macaroni, as well as a brisk coasting trade. Half a mile from the town, and close to the sea, are the mineral waters of Acqua Termo Minerale Nunziante, containing carbonate of

iron and magnesia, with an excess of carbonic acid gas, at a temperature of 90° Fahr.

The coast-line now trends more to the south, leaving Pompeii a mile inland, with the river Sarno following a winding course from the buried city through the low, flat land to the sea. As there are good grounds for believing that the ancient city of Pompeii was close to the shore, and at the mouth of the Sarno, it would seem that all this low area lying between the ruins of Pompeii and the sea, and on both banks of the Sarno, has been raised into dry land, if not at the time of the destructive earthquakes and eruption of 63 and 79, yet since the commencement of the Christian Era.

Leaving now the coast-line, the Vesuvian encircling road runs northwards, and at a little distance inland, and at the foot of the mountain, passes the town of Bosco tre Case, and then continues through the neighbouring town of Bosco Reale. These two places have together a population of nearly 8,000; they contain several churches and convents, a royal manufactory of arms, &c. They lie between Pompeii and the summit of Vesuvius, the route to which from that place passes them.

Continuing northwardly, the road crosses some spurs of the mountain, and the most northern of the eastern lava-flows. It passes Caposecchi and the woods of the Prince of Ottajano, and then behind the ridge of Monte Somma runs directly

to the town of Ottajano, a place of 6,000 inhabitants, chiefly engaged in agriculture, with a castle on a neighbouring commanding elevation. A line drawn from this town to Torre del Greco would cut through the cone of Vesuvius, from which they are both equally distant in a straight line. Ottajano is, however, protected by Monte Somma, and so it has not suffered at all from lava-flows, while Torre del Greco has been several times almost destroyed, yet the latter place has four times the population. Still further round the base of the northern slopes is the town of Somma, with a population of upwards of 7,000. It has several churches and monasteries, as well as the castle of the Prince. The country extending from this side of the base of the mountain inland is flat, and forms the famous plain of Capua, stretching eastwards to the Apennines that rise beyond the towns of Palma and Nola.

Coming round to the western side again, we reach the considerable town of San Anastasia, and further the village of Cercola, while the less considerable places called Trocchia and Pollena are situated on a higher level, and on the slopes below the Hermitage are the two closely adjacent villages of Massa di Somma and San Sebastiano, between which the long and unusually fluid lava stream of the eruption of 1855 flowed. The suburban towns of Ponticelli and Barra, with a population together of 10,000, and the village

of San Giorgio a Cremano, are situated on the low ground between Vesuvius and the city of Naples. In this neighbourhood are many large residences and villas of Neapolitans, and a very considerable area is covered with fruit gardens. The last-named village being close to Portici completes the ring of towns and villages with which Vesuvius is begirt.

Without doubt the greatest and most conspicuous feature of the surroundings or setting, so to speak, of Mount Vesuvius is the magnificent bay, which spreads its waters westwards from the very foot of the mountain. The Bay or Gulf of Naples, the Sinus Cumanus of the Romans, and the "Crater" of Strabo, is an expanse of water of over 52 miles in circuit, and has a shore-line, not measuring minor indentations, of 35 miles. Two bold headlands, the Capo di Miseno (Promontorium Misenum) and Punta della Campanella (Promontorium Minervæ), the horns of the great crescent, distinctly define its two extremities, and islands at a little distance from each well separate the bay from the open sea beyond.

Although the form of the landward outline, as shown by maps, is both irregular and angular, yet distance so softens all the angularities that to the eye the whole coast-line appears to be made up of sweeping curves, in admirable proportion to their backgrounds, as seen from whatever point of view may be chosen. The principal central curves are backed by two mountain masses, that of Vesuvius

and Somma, and that of Monte St. Angelo, behind Castellamare, both rising to upwards of 4,000 feet, Monte St. Angelo is 4,700 feet high, while the lower heights towards the extremities of the bay are rendered sufficiently bold by their proximity to the water's edge.

Below the water-line, in the central part of the bay, the shore has a very slight slope, corresponding with the low plain on which Vesuvius stands. The angle of the slope is only about 1°, increasing to 2°, and for a long distance out from land the bottom is covered with mud of volcanic material, for not until the deep water region between Ischia and Capri is reached is it found to be sandy.

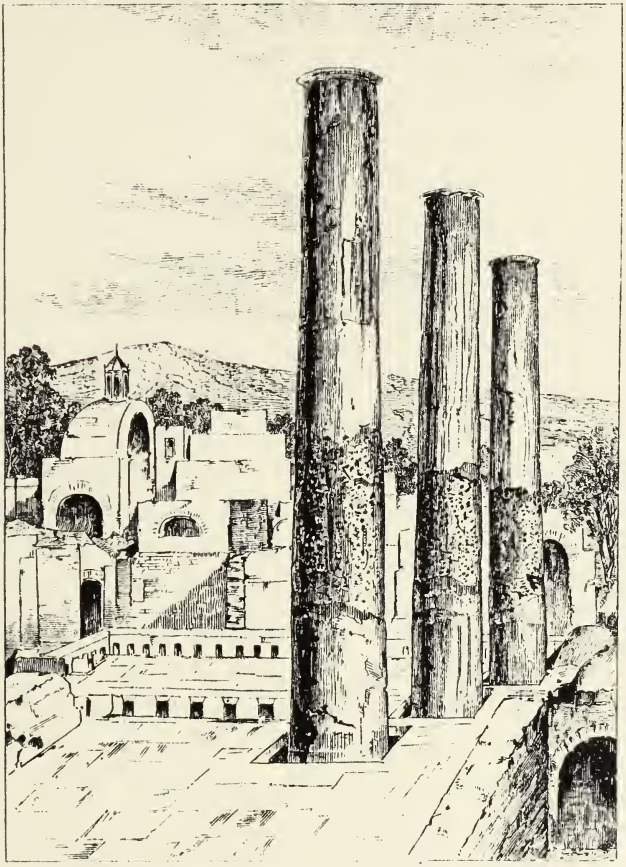
From every part of the surface of the bay a perfect panorama of its surrounding shores may be seen, since there is no large island to obstruct the landward view. A day's cruise in a yacht on the bright waters of the Bay of Naples may therefore be spent not only most enjoyably but most usefully, for nothing will be better calculated to impress the memory with the various prominent points and elevations and with their relative distances apart. But Naples itself, at the extreme northern corner of the bay, is most admirably placed for commanding a prospect of the coast to the south as far as the island of Capri, and especially for a general view of Vesuvius.

The centre of the sea-front of the city of Naples is about nine miles due west of the eruptive cone,

and therefore at a most suitable distance from which to obtain a good general view of the entire mountain and its more splendid and conspicuous phenomena. This position, Santa Lucia, near the Castel dell' Ovo, affords an excellent view, during a favouring eruption, of the fiery rivers on the north-western slopes, and here groups of people each evening congregate to witness the grand and striking scene; the grander and more striking from the dark plain of smooth intervening sea which mounts the picture, while adding to its charms by reflecting the glowing streams and the summit fires.

But before the traveller, journeying from Rome by Caserta in the evening, reaches Naples, he sees from the railway train the fires and the smoke of Vesuvius alarmingly near, and if he has never before seen a volcano in eruption, wonders at the indifference of the men employed on the line, whose safety, as well as that of the Strada Ferrata itself, appear to him to be very doubtful. The next morning, however, the newly arrived traveller has his anxieties and fears greatly allayed, if not altogether removed, for by daylight the scene is by no means so terrific. Instead of fiery streams or sheets on the mountain slopes, and a fiery glow above, the upper part of the volcano is partly hidden by steam, which rises from the lava on its sides, and culminates in a towering column above the summit of the cone, darkening as it rises, and, canopy-like, spreading

Plate VI.



RUINS OF THE TEMPLE OF SERAPIS.

out above and overshadowing the whole. This steam, which is given off by the flowing lava, and rises from out the crater in immense volumes, has the effect of obscuring the incandescent lava, and so greatly lessening the scenic effect of an eruption during the day, while it has quite the contrary effect at night, for it then, by reflecting the glow below, greatly increases the apparent size of the flows, and gives a flame-like appearance at the summit.

And as the day advances, and the sun gets round to the south, lighting up the margin of the bay and the long line of white houses and buildings separating the bright blue sea from the bright green slopes, gently rising and studded with villas, there is so much that is beautiful, so much that is peaceful, bountiful, and smiling, that all wonder at Neapolitan gaiety and indifference to the close proximity of a volcano, and to at least ordinary eruptions, is speedily dissipated. Even when actually on the slopes of Vesuvius in eruption, one cannot fail to be free from all fear, so exhilarating is the clear air of this Mediterranean coast. The mind refuses to think of possible evil or harm, and the spirit rejoices in the actual, pleasurable present, when every step is either among rich vineyards and gardens, or amidst surroundings of the utmost novelty and interest, while at every pause in the ascent the delighted eye looks round upon a scene of striking beauty, for it ranges over an expanse of sea and land which, for variety and the picturesque outline

of its general features, as well as for brightness and richness of colouring, is perhaps unsurpassed. The elegant curve of the shore-line, extending from the promontory of Misenum to the base of the rugged heights above Sorrento, separates the blue waters of the Mediterranean from the vine-covered plain of the Campania Felix. On the right, the noble city of the Siren with its long white arms embraces, as it were, its own lovely bay, while the rocky isles of Ischia, Procida, and Capri stud the azure surface of the sea. On the left, and at our feet, lie the ruins of once rich and populous cities that, with the other remains of ancient greatness with which this part of the classic land of Italy abounds, give an additional charm to a most interesting, most remarkable, and singularly beautiful portion of the surface of our globe.

CHAPTER III.

THE MOUNTAIN.

Name—Form—Both Typical and Peculiar—Five Parts—The Lower Cultivated Slopes—The Desert Platform—The Ridge of Monte Somma—The Great Cone—The Crater.

HOWEVER great may be the interest attaching to the Phlegræan Fields and their extinct craters, to the islands in the Bay and their volcanic structure, and to the surroundings of the mountain, it is to Mount Vesuvius itself that the attention of all is chiefly directed.

Though the name appears in Latin authors as Vesbius, Vesvius, and Vesevus, it is found as we have it at present in the Greek of Strabo, who uses the term ὄρος τὸ Οὐεσούϊον, and Diodorus Siculus employs the name of the mountain adjectively in ὁ τόπος Οὐεσούϊος. To the northern portion the name Monte Somma has been given, it is thought by some from a god of nocturnal lightning and storm called Sommanus, to whom a temple may have been erected on the northern slope above the plain to the west of the town of Somma. Frequently the name Monte Somma is used by writers somewhat loosely, sometimes to designate the whole of the northern side from the crest to the base, and sometimes as applicable only to the uppermost part of this side of the mountain. It will be in the latter more restricted

sense that the term will be here employed, since the lower slopes on every side are really parts of the base of the same mountain, and the Italian word "monte" is very generally applied and restricted to an upper part of a mountain, and even to a peak or summit only, as it is to the elevated points along the crest of Somma itself.

The mountain mass to which the general name of Mount Vesuvius is given, rises grandly on a wide-spreading circular base of nearly thirty miles in extreme circumference, to a height of upwards of 4,000 feet above the level of the sea. On all sides but one it rises from the low, flat Campanian plain, and on the remaining one, the south-western, from the shore of the Bay of Naples. It is therefore an isolated mountain without connection with any other, not even with the tufa hills of the vicinity of Naples. Its form is, however, very unlike the simple conical figure of volcanoes generally. Vesuvius is a peculiar and somewhat complex volcano, and is therefore, apart from the frequency and character of its eruptions, of much more than ordinary interest to the geographer and the vulcanologist, combining, as it does, the most interesting features and characters of volcanoes generally.

The great peculiarity of Mount Vesuvius is that there are two peaks of nearly equal elevation, each of which is of a typical volcanic character. There are consequently, as it were, two volcanic masses of different types combined in one mountain, and they

are, moreover, representative examples of the two great classes of volcanic mountains, the extinct and the active.

One of the peaks is the highest point of a long semi-circular or sickle-shaped ridge, having the usual volcanic slope on its outward or convex side continuous with the lower slope of the mountain below, and a precipitous face on its inward or concave side. It is therefore precisely analogous to those great crater walls that surround the Calderas, or extinct craters of the Canary and other volcanic islands, whose fires have been long since extinguished, and there can be no doubt whatever as to its being a portion of such a crater wall. To this the name of Monte Somma is properly applicable.

The other peak is a typical conical one, with a cratered and consequently truncated summit, and this is the present eruptive cone of the volcano, the summit of which, being now higher than the summit of Monte Somma, is the summit of the whole mountain.

These two uppermost portions of the great mountain mass have, furthermore, a particular and special relation to each other, for the conical portion stands partly within the curve of the semi-circular ridge, and on the centre of the circle of which this ridge forms a portion. The cone is thus half encircled by the ridge of Monte Somma, and consequently the great crater of which Somma formed a part must have been produced by volcanic action

proceeding from the same central vent as that of the eruptions of the modern Vesuvian cone. It is therefore evident that the two uppermost parts of the mountain are but the productions of the eruptive energy of the same volcano during two different epochs.

As the bay is crossed from Sorrento to Naples, the outline and form of Vesuvius appear gradually to change. First there is seen a conical mountain with a projection, or end of a collar, so to speak, at each side of the upper portion, in consequence of the cone from this point of view being in front of the middle of the Monte Somma ridge; and then, as Naples is approached, more and more of the high, sharp ridge of Somma comes into view on the northern side, while the end of the ridge on the southern side disappears, until at length two separate and distinct peaks crown, mitre-like, the great mountain mass. It is therefore from the city of Naples itself that the characteristic form of Mount Vesuvius is best observed.

The outline of the mountain, as seen from Naples, is on its southern side a singularly graceful curve, slightly concave, rising very gently from the low grounds, and continued with a gradually increasing inclination to the summit of the cone, with, however, a protuberance or small elevation above the line of the general curve, at about half way to the summit, called La Pedamentina. On the northern side, the outline corresponds with that on

the south for a considerable distance from the plain, and then increases rapidly in inclination to the summit of the ridge of Somma that stands on the same level, and the outside of which is at the same distance from the centre of the cone as the Pedamentina.

The whole mountain may be described as consisting of a great circular base or lower portion, rising very gradually from the plain, and having two comparatively small mountains standing upon it, one a cone with a truncated, or, rather, rounded or dome-like summit, over the centre of the whole, and the other a semi-circular ridge, a little less in elevation than the cone which it half encircles, and to which it presents an opposing, precipitous, and almost perpendicular face. And since the surface of the great body or lower portion of the mountain is conspicuously divisible into two areas, one formed of the lower cultivated slopes and the other being a platform-like expanse which is altogether desert, for purposes of general description five parts of the entire mountain may be consecutively considered. These may be conveniently designated as follows :—

1. The Lower Cultivated Slopes.
2. The Desert Platform.
3. The Ridge of Monte Somma.
4. The Great Cone.
5. The Crater.

The Lower Cultivated Slopes.—The lower slopes of the mountain spread out so widely and merge so gradually into the flat land of the basal plain, that it is difficult to draw an exact line of demarcation between the plain and the foot of the mountain; but the length of the circumference previously stated, nearly 30 miles, may be taken as a sufficient one to include all that properly belongs to Vesuvius. Within this line the angle of the inclination of the land is at first very slight, and it increases very gradually, 1°, 2°, 3°, and so on, until about 10° or 12° may be taken as the maximum general inclination of the lower cultivated slopes. Many of the surrounding towns and villages previously noticed are built on the foot of the mountain itself, and the ring-road of twenty miles connecting them is consequently somewhat above the level of and inside its extreme circumference.

Above the ring-road, for a distance of about a mile and a half up the slope of the mountain, extends the region of gardens and vineyards, constituting, with the similar area below the level of the road, a zone of cultivated and highly productive land more than two miles in width, and having an area of about forty square miles. Except where seamed with undecomposed lava or grooved by an eroded gully or fosse, the surface of this extensive area consists of deep rich soil.

The productiveness of the soils of volcanic districts is due to the decomposition of volcanic

materials, which, containing silica, alumina, magnesia, lime, potash, and iron, give to the soil formed from them the substances which, with the carbon and nitrogen derived from the atmosphere, furnish abundantly the elements required for plant growth.

When the felspar of granitic rocks is decomposed a bed of pure clay, kaolin, is produced, but the result of the decomposition of the felspar of ordinary volcanic rocks is a friable and easily worked soil. This different result is caused by the associated and disintegrated minerals in the case of granite being refractory and distinctly crystallised, and consequently easily separable from the argillaceous matter resulting from the decomposition of the felspar, which is left as a mass of clay, while in volcanic rocks the associated minerals are intimately intermingled and are themselves decomposable.

Occasionally, however, the decomposition of volcanic material produces a clay, as in the case of some trachytes, which are very largely composed of orthoclase felspar. Indeed, so preponderatingly felspathic is some trachyte, that it decomposes into a white kaolin, as in one locality of the Roman Volcanic Region, where a clay derived from a trachyte gives so white a colour to the soil around one of the villages there that the place is named Bianca.

There is a very great difference, however, in different districts both in the time required for the formation of soil, and in its fertility when formed. Augitic or pyroxenic lavas are more quickly decom-

posed and produce more fertile soil than trachytic, in consequence of a more complex composition, and their felspar being a lime instead of a potash felspar. Dr. Daubeny states that the trachytic lava of Epomeo, in Ischia, which was emitted in the year 1302, was at the time of his visit to that island quite undecomposed, while the augitic lavas of the Vesuvian eruption of 1631 were then covered with rich soil forming luxuriant garden ground.

Lavas, too, in a vitreous condition are less easily decomposed, and as pumice is but a mass of fibrous, filamentose, or vesicular vitreous lava, it resists the action of the atmosphere in an extraordinary manner. The pumiceous lapilli of Pompeii, although not trachytic as formerly thought, but of similar chemical composition to the dark-coloured lavas of Vesuvius,* is to this day quite unaltered, notwithstanding the fact that from the spongose texture of the material itself, and the loose and open character of the accumulation, air and rain-water have been freely admitted to it for more than 1800 years. Pumice, too, dredged from great oceanic depths is found to be quite unchanged.

As has been stated, volcanic soils are remarkably well adapted for the growth of vines, from which the choicest wines are produced, as well as for fruit generally, and as evidence of how great may be the growth of timber upon them, it may be here men-

* "On the Geology of Monte Somma and Vesuvius," by Dr. Johnston Lavis, *Quarterly Journal of the Geological Society*, vol. xl.

tioned that in the Forest of Carpinetto, on the flanks of Etna, the Castagno di Cento Cavalli, or chestnut of one hundred horsemen, has five trunks of 163 feet aggregate girth at a few feet above the ground, and a diameter of about fifty feet. Within the compass of the five trunks one of the Queens of Arragon took shelter with 100 horsemen. There is another tree here of twenty-five feet diameter, one of eighteen feet, and another of fifteen feet.* Nevertheless, Brydone states that the Canon Recupero told him he had calculated that 2,000 years was required to form a scanty layer of earth on a lava. This can only be explained, in face of the abundant facts to the contrary, by supposing the Canon to have referred to pumiceous deposits.

Rising conspicuously above the general slope between Torre del Greco and Torre del Annunziata, the elevation on which stands the convent of the Camaldoli della Torre adds a wooded knoll to the cultivated area, which is here, however, at each side of the hill, considerably trenched upon by recent lavas. The ground on which the convent stands is 600 feet above the level of the sea, and sufficiently above the contiguous surface to ensure safety to both the buildings and the trees from lava flows, which continue their course on one or both sides of the knoll.

At a higher level, but still well within the cultivated region, the "bocche" or mouths of the eruption of

* "Etna," by G. F. Rodwell, page 39.

1861 are seen more immediately above the town of Torre del Greco, which suffered so severely from the lavas they poured forth. They have a linear arrangement radially extending down the slope for nearly 700 yards between the contours of 900 and 800 feet above the sea-level.

The bare lava-rock of the 1861 eruption will be found extending from the bocche to Torre del Greco, and near it that of the eruption of 1794, which flowed from bocche at a considerably higher level, from about 1,200 to about 1,500 feet. Near and around the Camaldoli are the lavas of 1804, 1805, and 1806, while in the neighbourhood of Bosco tre Case the lavas of 1850 are met with. Further east, the great flow of 1834 is seen occupying a large area, and extending as far as Caposecchi, quite at the junction of the foot of the mountain with the plain, a distance of nearly four miles and a half from the point of emission.

On the western side the equally long but narrower lava-flow of 1855, after passing between Massa di Somma and San Sebastiano, reaches almost to Cercola, and the last great flow, that of 1872, branching westwards from the same course as that of the 1855 lava, spreads out and terminates at Le Novelle de Resina.

These lava-flows and older ones now concealed under those of more recent date, or beneath the result of their own surface decomposition, the deep rich soil of the cultivated area, have chiefly flowed

from the upper portion of the mountain through four hollows, or ravines, called "fosse." They are the Fosso Faraone on the west, at the end of the Somma ridge; the Fosso Cupaccia on the east, at the other end of the ridge; and, furrowing the south-western slope, the very important intermediate Fosso Grande, with the Fosso Bianco above Torre del Greco. But the emission of lava in 1631 was so copious that it formed no less than seven wide floods, which, spreading as they descended, covered several large areas extending to the sea, with lava-rock. This lava, except where cut through or exposed at the sea-shore, is masked by the soil it has produced, and the area devastated has consequently been restored to cultivation.

The cultivated ground of the lower slopes below the protecting ridge of Monte Somma differs from that on the unprotected side of the mountain, in being quite free from recent undecomposed lava-rocks intersecting the vineyard land, and also in rising to a much higher level. It is, however, traversed in its lowest parts by eroded furrows, called "lagne," and in its upper part by the more important and deeper "vallone." These latter are numerous, upwards of thirty being named along the whole length of five miles. At the western end there are the Vallone della Vigna, the V. del Piano, the V. del Sacramento, and then the V. Cancherone and the V. Gaude are followed by the Vallone di Castello, in which is situated on an

eminence Santa Maria di Castello. Near the town of Ottajano are the V. Fosso dei Leone, the V. di Palmenticello, the V. Constantinopoli, the V. del Bosco, the V. Scuro, the V. di Sanseperino, and the V. di Pietra Pomice. Still further, there are the V. della Trofa, the V. Casella, the V. degli Spiriti, the V. Cutolo, the V. di Recupo, and the V. Mazzamei, followed by the V. Nascosto, the V. Tagliente, the V. dei Cerri, the V. di Nicolo, the V. della Profica, and the V. di Cola, and at the extreme end of the ridge, at the Bosco di Cupaccia, there is the widest one of all, called the Vallone Grande. In this region, on the slopes in the neighbourhood of the town of Somma, a lofty elevation, called Monte Saint Angelo, rises to a height of 1,476 feet above the level of the sea.

The Desert Platform.—The desert region forming the platform on which stands the great cone of Vesuvius has a surface sufficiently level to be called a plain, or "Piano," and it is doubtless in consequence of the slope being here so little that it presents the barren and desolate appearance in such striking contrast to the aspect of the cultivated area, since lavas from the cone have in the case of moderately large flows spread over the surface, and so cooled and solidified, without extending to the lower slopes, and in the case of small streams the movement has been so slow that rapid solidification has confined the lava to the piano. Thus this comparatively level area has been so frequently covered

with fresh lava that there have not been sufficient intervals of time for decomposition to affect its surface, and accordingly it has been continuously an area of hard, undecomposed lavas.

The Desert Platform has a circuit of about seven miles, one portion having a width of a mile and a half, and the other, that between the foot of the cone and the base of the precipitous rocks of Somma, of only a quarter of a mile. Nothing can well be more distinct and conspicuously marked, except perhaps the division between land and sea, than the differentiation of the cultivated land and the region of undecomposed lavas. On one side of a wall a most productive and highly cultivated vineyard may be found, and on the other a desert of hard black rocks, without a trace of vegetation.

The whole of this portion of the mountain surface is clearly divisible into two parts, one the area lying between the foot of the great cone on its northern and eastern sides and the ridge of Monte Somma, and the other that on the southern and western sides of the cone, and unbounded by an exterior enclosing ridge.

The last-mentioned area is a very extensive one, being about five miles along its outer curve and a mile and a half across, thus giving an area of nearly seven square miles. The commencement of the piano is about 1,500 feet above sea-level, and the base of the great cone 2,500 feet, so that the difference of level between the lower and the higher

boundaries is 1,000 feet, while the breadth may be taken at 8,000 feet. This shows a mean inclination for a very large section of the surface of the mountain side of only 1 in 8, or 7°. This large area is called La Plaine, and a portion towards the edge is named the Piano del Ginestre, which, terrace-like, overlooks the south-western seaward slopes below, with the towns of Torre del Greco and Resina, and to the right Portici, with its palace and beautiful gardens and park on the lower ground extending to Granatello next the sea. To the south-east of the Piano del Ginestre the Pedamentina rises above the general level of the edge of the platform, and so forms a shoulder on the Vesuvian profile, as seen from Naples.

On the northern side of the Piano del Ginestre, but separated from it by the Fosse Grande, rises a conspicuous ridge-like hill of great interest, for on this elevation stands Professor Palmieri's celebrated Vesuvian Observatory, containing his seismographic apparatus, and at a little distance is the Hermitage and the ancient chapel and shrine of St. Salvatore, while at the extreme end of the ridge fronting the great cone is a cross, "La Crocella." The summit of the hill where the Observatory stands is 2,080 feet above the level of the sea, and at this level, at the Hermitage, is a well of good water. The Hermitage is a convenient stopping-place, a sort of half-way house to the summit, where a mule may be stabled, and both water and the

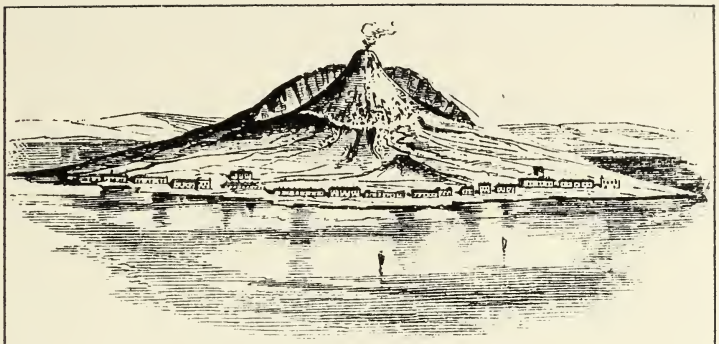


FIG. 1. VIEW OF VESUVIUS FROM SORRENTO.

FIG. 2. VIEW OF VESUVIUS FROM NAPLES.

FIG. 3. VIEW OF VESUVIUS FROM NOLA.

LONDON; HOPER & DROWLEY, 11 LUDGATE HILL, E.C.

ordinary wine of the country, if not Lachrymæ Christi also, may be procured.

On one side of the hill the Fosso della Vetrana receives flowing lava from the north side of the cone, and conveys it to the Fosso di Faraone below, and on the other side the Fosso Grande similarly receives the fiery floods from the western side. Sometimes, too, a large flood of lava is divided by the Crocella end of the ridge into two flows, one of which enters the Fosso della Vetrana, and the other the Fosso Grande, with the hill and its crowning Observatory standing quite unscathed between. Thus it is rendered possible for Professor Palmieri to remain at the Observatory night and day during even a very violent eruption, such as that of 1872, and, as an intrepid soldier of science, with a sheet of red-hot lava on each side, to brave their dangers, as well as those of projectiles and possible fissures, in order to observe and record the ever-changing aspects and phases of a great eruption.

The Observatory is a handsome and cheerful-looking building of white stone, affording a welcome relief to the eye in this region of black lava, and inviting the visitor by its appearance to enter and inspect the ingenious and delicate instruments by which the Professor is notified of every tremor and palpitation of the heart of old Vesuvius. (See Appendix.)

The shrine of S. Salvatore, where is entombed the body of the saint, is a very ancient one, and it

has been suggested that possibly at this place stood a temple to the god Sommanus, from which deity Monte Somma is supposed to obtain its name. La Crocella, the Italian word for a little cross, by which the wooden cross at the end of the ridge is known, is often used as a name for the hill itself, though it is also frequently called the Observatory Hill, and sometimes the hill of San Salvatore.

Extending round the northern and eastern sides of the great cone, and hemmed in by the lofty and frowning precipitous rocks of Monte Somma, is situated the second of the two divisions of the desert platform of the mountain. To this weird-looking, deep, and perfectly desert, but almost regularly semi-circular valley, the general name of Atrio del Cavallo, or the court of horses, is given,* though its eastern and somewhat more restricted end is specially called the Valle dell' Inferno, or sometimes the Canale del Inferno. Throughout its entire length of upwards of two miles the valley has an approximately level bottom, with an elevation above the level of the sea at the end opposite the Crocella of 2,624 feet, and at the Valle dell' Inferno, near the eastern end, of 2,493 feet, or only 131 feet of difference in the two miles.

From the peculiar structure and position of the

* Since horses used in the ascent of the mountain were frequently left here in consequence of not being available for the ascent of the Cone.

Atrio del Cavallo it forms a most conveniently placed receptacle for all lava flows from the northern side of the cone, and these, by their separate solidification, have formed floor above floor, and so a modern level-topped mass of lava-rock of considerable thickness has been accumulated between the foot of the great cone and the bottom of the concave side of the ridge of Monte Somma. It has been estimated that there is a thickness of fully 100 feet of such lava-formed rock in the Atrio del Cavallo at the base of the Somma cliffs, by which their height above has been correspondingly diminished.

THE RIDGE OF MONTE SOMMA.—It is not too much to say that, although the Somma ridge has a structure that is typically volcanic, and quite similar to that of the walls of insular calderas and other extinct volcanic craters, yet it is unique in its combination of elevated position, limited extension, and abrupt termination at each end.

Standing at an elevation of about 2,500 feet above the level of the sea, and commencing and terminating with lofty elevations, this old crater wall does not extend further than less than half way round the circle of which its curved outline forms a part. The length of the inner semi-circular face of the ridge, from the commencement at the western end, near the Crocella, to the eastern end of the Valle dell' Inferno, is two miles, and the general height of the middle part of this face above the level of the Atrio del Cavallo is about 1,000 feet. The highest

point is called the Punta del Nasione, which rises to 3,730 feet above the level of the sea, and near to it on one side is Monte Ottajano, 3,653 feet, and on the other, Monte Trocchia, 3,582 feet. At the Crocella end the Primo Monte rises to 3,149 feet, and the two prominent highest points between Monte Ottajano and the eastern end have elevations of 3,471 feet and 3,084 feet respectively.

It will thus be seen that the crest of Monte Somma is a serrated ridge with an almost vertical face on its inner concave side, and a sloping face on its exterior convex side. The exterior slope is roughly parallel with that of the great cone, the angle of inclination corresponding with that of volcanic cones generally, and in distant pre-historic ages this was probably a part of the slope of a cone that towered far above the present elevation of the mountain. Though the crest of Somma has not been affected by volcanic action for 1,800 years, yet it has been subjected to those continually acting weathering influences that gradually erode and wear down the topmost heights, and furrow the sloping sides of all mountains. Hence the exterior slopes of the ridge are sculptured with furrows commencing from between its highest points, and extending downwards to the vallone of lower levels. Weathering action has also removed all the loose materials from the loftiest parts, by which the uppermost slopes are rendered bare of all vegetation, but in many places woods and trees occupy very high ground, and even

vineyards may be found at elevations above the 2,500 feet contour.

THE CONE.—The present eruptive cone of Vesuvius, the seat of the visible phenomena of our day, is the part of the mountain that is of especially great interest. Compared with the whole mountain mass it is a minor portion, but it is nevertheless of very considerable dimensions, having a base of about three miles in circumference, and an altitude which may, perhaps, be stated as being now normally about 1,500 feet, though this may be much reduced by a more than ordinarily violent eruption, while every small eruption adds to the height and tends to complete the apex of the cone.

Much misconception exists respecting the steepness or angle of inclination of the slope of the sides of the cone. This is in a great measure due to the ascent being made in a direct line to the summit, there being no pathway, either winding or zigzag, to enable the climber to avoid facing the slope which, rising directly in front of the eye, has, consequently, the effect of appearing to be much steeper than it really is. The impression of great steepness is deepened by the character and condition of the materials of which the surface of the cone is composed, for the loose, dry scoriæ yield to the tread, and so each individual stride is made both longer and steeper, while the momentum of the body's upward motion is diminished, and

progress consequently rendered much slower and more laborious than if the tread were on firm ground, while the vertical faces of the larger masses standing above the general slope increase the apparent steepness of the whole.

The inclination is, however, only an ordinary hill-slope, not nearly so great as that of many hills and mountains in England that are not unfrequently ascended without being considered of extraordinary steepness. The angle of the slope has been repeatedly measured, and found to range from 30° to 40°. By careful measurement with pole and clinometer it was found by myself to be 40° at the steepest part of a direct line from the Atrio del Cavallo to the summit, and even this moderate angle of inclination may have been caused by temporary local conditions, since it sometimes happens that a very small flow of lava cools on the slope and so entirely solidifies before reaching the foot, and thus a local and temporary increase of the normal gradient may occur along a portion of some one meridian, so to speak, of the cone. The majority of measurements appear to give 34° as the mean normal angle of the general slope, which slightly increases towards the summit. Yet published statements of the angle of inclination are frequently incorrect. Soon after the construction of the Funicular Railway from the base to the summit of the cone, it was stated in a journal of great authority that the inclination of the line was 40°,

increasing to 63°, and was at 50° at the uppermost part!

The size and steepness of the Cone of Vesuvius may, perhaps, be better realised by a comparison with the well-known conical elevation of north-western London, Primrose Hill, which stands on a base about one-fourth as large, but is only 100 feet in height, and has an upper slope of 10°.

The summit of the Cone, and of the whole mountain, can only be described as variable and almost constantly varying, since it is altered or modified by every eruption, and indeed by even slight activity not sufficiently pronounced to be called an eruption, while its loose materials are acted upon by weathering agencies when volcanic action is quite dormant. Slight activity when prolonged sometimes fills or nearly fills the crater with lava, when the weight of the fluid mass may break down a portion of the encircling rim, and so cause a depression on one side, over which the lava will flow.

An opening through the side of the cone, by giving a lower way of exit for the lava, then reduces its height in the volcanic tube, and so empties the crater of lava, but at the same time, together with ashes, semi-fluid or plastic masses are ejected that, cooling as they descend, fall as solid scoriæ around the central vent, and so very soon a small cone is there formed, which, gradually growing from the accumulated ejectamenta of continuous or intermittent slight activity, may in time rise as high as

the level of the crater walls, with but a small opening at the apex. A subsequent moderate eruption removes this small new cone, throwing its materials high into the air, and then commences the formation of another but larger cone inside the great crater that speedily increases both in height and bulk until it overtops the surrounding crater rim, and even fills up the intermediate circular hollow.

This last-formed cone is left with a crater of considerable dimensions, the walls of which will then furnish loose material that on the subsidence of the lava falls into the volcanic tube and chokes it up, and a floor of such material is subsequently formed for the crateral hollow, on which may, perhaps, be found one or more fumaroles giving off sulphurous acid, carbonic acid, or other gases and fumes.

So the summit may remain until a violent eruption removes all the infilling of the volcanic tube, all the floor and all the walls of the last-formed crater, all the accumulated material in the great crater, and even, in the case of an unusually great or "paroxysmal" eruption, part of the walls of the great crater itself, and so reduces the total height of the mountain.

Thus it is that the summit of the Vesuvian cone, from the frequency and great variability of character, duration, and intensity of the eruptions, possesses an unusual amount of interest, and thus it is, too, that the height of Vesuvius above the level of the sea can only be given approximately, the elevation

of one year being liable to be altered the next by even hundreds of feet, as was the case in 1821 and 1822, when the great cone was diminished in height by 800 feet, reducing it to only the lower half of a complete cone.

A point on the rim of the great crater, on its northern side, has had a rather prolonged existence, and it has therefore been regarded as an approximately fixed point. This is the Punta del Paolo, which owes its continuance to being a point at the side of a depression on the rim of the crater of the greater eruptions, which can only be enlarged and the Punta destroyed by a paroxysmal eruption of much more than usual violence. Its elevation is given as 3,949 feet. It may, however, be overtopped, as before stated, by a new cone formed by moderate eruptive activity, and in this case a small terrace may be formed on a level with the Punta surrounding the new cone. Thus the side of the cone may in its profile show an angle near the summit, the uppermost portion being formed by a new cone, which may rise to perhaps 300 feet above the level of the Punta del Paolo, as was the case in 1868, when the extreme height, according to Palmieri, was 4,255 feet.

An interesting list of measurements of the elevation above sea-level of the Punta del Paolo was given by Prof. J. D. Forbes in his "Physical Notices of the Bay of Naples," * and, with the

* Brewster's Edinburgh Journal, 1829.

heights stated in English feet, may be here reproduced.

	Feet.
Saussure, 1773, barometric measurement ..	3894
Poli, 1794	3875
Breislak, 1794	3919
Gay Lussac, Von Buch, and Humboldt, 1805 ..	3855
Brioschi, 1810, trigonometric measurement ..	4079
Visconti, 1816	3977
Lord Minto, 1822, barometric measurement ..	3971
Scrope, 1822	3862
Monticelli and Covelli, 1822	3990
Humboldt, 1822	4022

The Crater.—The crater is the most characteristic part of a volcano, proclaiming at once the igneous origin of the mountain, however quiescent it may be, even, indeed, when there are no volcanic rocks around, as in the case of the remarkable crater of the Meerfeld, in Germany, which is surrounded by slatey rocks. Craters produced by single eruptions, as that of Monte Nuovo and others in the Phlegræan Fields, as well as those of the Eifel, in Germany, are perfectly simple circular cup-shaped hollows with more or less lofty walls; but the Vesuvian crater is by no means so simple, for it is scarcely too much to say it is almost constantly changing. Sometimes, it is true, it is a great cup-shaped hollow, but it does not long remain so. The process of alteration, as previously stated, at once commences, and more and more complexity follows, until sometimes it is not merely double, but treble, and quadruple, and even as many as five craters have been found within the great crater-rim, as was the case in 1884.

The eruptive crater of any eruption of Vesuvius is only coincident with the great crater when the eruption is an unusually violent one, which removes all internal cones and crater-walls, and leaves but a single deep as well as wide crater, with steeply descending sides. After a series of moderate and small eruptions, the floor of the crater may be a level bed of solidified lava, with but low walls around, and a small cratered cone rising in the middle or near one side. Sometimes, too, when such a floor has been formed, an opening or fissure may be produced by the falling in of a portion, and sometimes two craters, divided only by a wall, may be seen side by side, and sometimes, too, a small crater or bocca may open on the crater-rim itself. When a passage in the side of the cone allows of the discharge of the lava at a lower level, the brim of the eruptive crater may be quite continuous and regular in height throughout the entire circumference, but frequently it is lower at some part from having given way to the pressure of the lava within, and a lip is formed, over which is then poured the fiery flood. Rents or fissures may also cause indentations in the rim, so that the bounding wall of the crater of a lava-emitting volcano is rarely quite uniform or regular in height all along the circumference of its rim.

The Vesuvian crater, like those of the great majority of volcanoes, is a true summit crater, but there are some notable instances of lateral

craters. The great crater of Kilauea, in the island of Hawaii, is on the side of Mauna Loa, 10,000 feet lower than the summit of the mountain, which, indeed, has another crater; and the constantly active crater of Stromboli is also on the side of the cone, though nearly at the summit. At Etna the great depression on the mountain side, called the Val del Bove, has been a lateral crater, but the present eruptive crater of this great volcano is at its summit.

Small temporary crater-mouths (bocche or "voccole") have been frequently opened on the side of Vesuvius, of which those formed during the eruption of 1794, at about 1,500 feet above the level of the sea, and those of 1861, of only 800 feet elevation, are notable examples.

Much interest is given to the interior of the eruptive crater by the fumaroles from which issue gases and steam, and on and about which sublimations are abundant and beautiful. During quiescent or normally uneruptive periods, or even during times of slight activity, there is no difficulty or danger in entering and inspecting the interior of the crater. Those who ascend Mount Vesuvius at such times, and who do not therefore witness the grand spectacle of an eruption with its impressive phenomena, have the, to some extent, compensating advantage of being able to closely inspect the interior of the crater, the mouth of the volcanic vent, and observe thereby many interesting volcanic

phenomena that cannot be seen during a great display of eruptive energy.

Thus it will be found that each of the five divisions of the surface of Vesuvius presents peculiar and special features and characteristics of great scientific as well as general and scenic interest, which combine to render this volcano, even when quiescent, perhaps the most interesting mountain in the world.

CHAPTER IV.

HISTORY TO 1850.

Numerous Records—The Pre-Historic Volcano—Vesuvius Dormant—Recognition of Igneous Indications by Ancient Writers—Renewal of Activity—Destruction of Pompeii—Formation of the Cone—Mediæval Eruptions—Eruption of 1631—Eruptions of Modern Times.

THE peculiar and remarkable structure of Vesuvius is consequent upon a remarkable history, the earlier chapters of which can only be read by a study of the rocks of the older portions of the mountain, but its later, and especially its latest, epoch has had numerous historians, some it is true of little power of accurate observation, but many were both accurate observers and graphic narrators. From Diodorus Siculus to Monticelli a long list of names of observers and recorders of Vesuvian phenomena could be given, whose accounts have furnished materials for a most interesting and instructive record of the eruptive energy of the world-famed Campanian Volcano during the last eighteen hundred years.

These accounts were collected by Dr. Daubeny, who collated them in the second edition of his "Volcanos" (1848), and a summary of this was given by Sir Charles Lyell in the "Principles of Geology." This history was succinctly reproduced

by Prof. Phillips in his work on Vesuvius in 1869, with an extension bringing down the record to the year 1868.

Although the phases passed through during the earlier periods of the volcano can only be deduced from a knowledge of its geology, yet the general configuration and structure of the mountain conspicuously indicate the existence of a pre-historic volcano of a simple conical form and of large dimensions, one with a base of nearly equal circumference with that of the present day, and an altitude far exceeding the greatest elevation of the summit during modern times, probably seven thousand feet.

This great pre-historic volcanic mountain must have been reduced in height by, it may be, one, or, it may be, by more than one great and paroxysmal eruption, that at the same time increased the size of the crater, leaving a vast area enclosed by an amphitheatre of rocks seven miles in circumference, with precipitous sides rising to a height of upwards of a thousand feet. Thus the mountain remained during many centuries without any display of volcanic activity, its long sleep continuing through the Roman period until the first century of the Christian era. Indeed, at the time of the Second Servile War, the crater supplied a place of refuge for Spartacus and his followers, who encamped within its lofty protecting walls.

During this prolonged epoch of dormancy the form of the mountain was very different from that which in our times attracts the eye by its picturesque

yet beautiful outline. Instead of a grandly swelling cone and a sharp serrated ridge standing on a widely spreading base, there was a simple truncated cone of great width and comparatively small height, for the present eruptive cone did not then exist, and the semicircular ridge of Somma of our day extended round the area on which the cone now stands, forming an irregular circle, and being the old crater-wall of the pre-historic volcano.

Vesuvius would consequently at that time appear from a distance as a broad circular mountain with an irregularly horizontal summit, a "table mountain" in fact, and it was only by an ascent to its top that the crateral cause of the low truncation of the wide-based cone could be ascertained. But those who did make the ascent to the rim of the old crater, and then descended the steep and rugged walls, found the arena, so to speak, of the great amphitheatre to be a bare and sterile plain, but the enclosing sides of lofty rocks to be covered with wild vines extending from the top to the bottom.

Little wonder, therefore, that the great mountain, so prominent as a land-mark to the gubernatores of Roman galleys, and that rose so gracefully, yet so majestically above Pompeii and Herculaneum at but a few miles from Neapolis, was not then generally known to be volcanic. To us moderns, however, with our extended knowledge, the structure of the mountain and the rocks of Somma at once reveal the volcanic origin of the whole, and clearly show

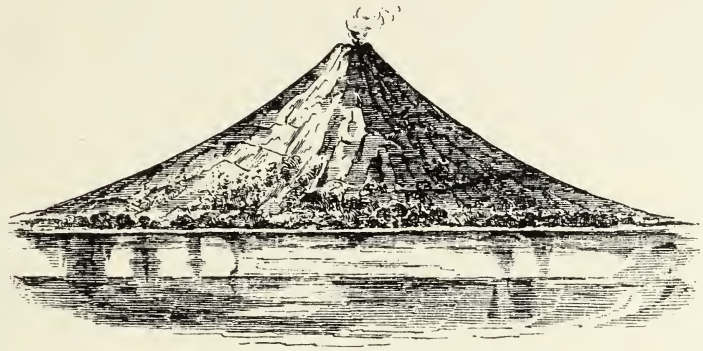


FIG. 1. VESUVIUS IN THE PRE-HISTORIC PERIOD

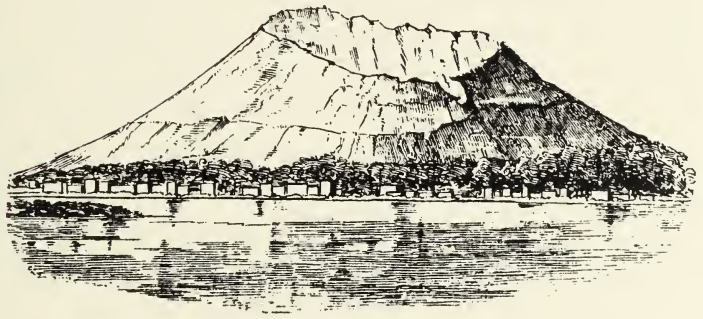


FIG. 2. VESUVIUS IN THE CLASSICAL PERIOD

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that although the volcano had been dormant for many centuries, yet at a pre-historic period, eruptions perhaps more terrific than any that have been recorded since the renewal of its activity, had covered its sides with red-hot lava, and had ejected scoriæ and ashes in immense quantities from a crater many times the size of the present one.

But there were not wanting amongst the observers of Nature of the ancient world some who saw, or thought they saw, indications of previous volcanic fires and eruptive action. Among the writers of antiquity who noticed or suspected the volcanic character of Vesuvius, the most notable were Diodorus Siculus and Strabo. The former of these ancient observers, a native of Agyrium at the foot of Mount Etna, was born on volcanic ground, and two eruptions of the great Sicilian volcano occurring during his lifetime, he was well fitted to detect the signs of volcanic action. These signs he observed at Vesuvius, and was thus the first to read in its rocks the igneous and volcanic character of the mountain. In his fourth book he says, "The entire district was called Phlegræan, from the culminating point, which is now called Vesuvius, bearing many indications of having given forth fires in ancient times." *

Subsequently Vitruvius, in writing on the tufa of

* Ὠνομάσθαι δὲ καὶ τὸ πεδίον τοῦτο φλεγραῖον ἀπὸ τοῦ λόφου τοῦ το παλαιὸν ἄπλετον πῦρ ἐκφυσῶντος, παραπλησίως τῇ κατὰ τὴν Σίκελίαν Αἴτνῃ. καλεῖται δὲ νῦν ὁ τόπος Οὐεσούιος, ἔχων πολλὰ σημεῖα τοῦ κεκαῦσθαι κατὰ τοὺς ἀρχαίους χρόνους.

Pozuolli, mentions a tradition that fire had at one time been seen coming forth from Vesuvius. Strabo, however, like Diodorus Siculus, inferred its volcanic origin from the appearances presented by the rocks around the crater.*

The year 63 of our era witnessed the earliest indications of renewed activity, and in the early part of that year, we are told by Seneca, that an earthquake occurred, which destroyed a considerable portion of both Herculaneum and Pompeii, and shook all the district surrounding the mountain. In the following year, a second earthquake caused considerable injury to the city of Naples, and it is said that the theatre, in which the Emperor Nero had been performing a short time before, was thrown down. These premonitory symptoms were followed, during the reign of the Emperor Titus, and in the year 79, by the famous eruption which not only destroyed two flourishing cities and completed the ruin of a third, but altogether altered the form and appearance of Mount Vesuvius. As this

* In his fifth book of Geography (E. 4, 8) Strabo writes :—

Νώλης δὲ καὶ Νουκερίας καὶ Ἀχερρῶν, ὁμωνύμου κατοικίας τῆς περὶ Κρέμωνα, ἐπίνειόν ἐστιν ἡ Πομπηία, παρὰ τῷ Σάρνῳ ποταμῷ καὶ δεχομένῳ τὰ φορτία καὶ ἐκπέμποντι. ὑπέρκειται δὲ τῶν τόπων τούτων ὄρος τὸ Οὐέσουιον, ἀγροῖς περιοικούμενον παγκάλοις πλὴν τῆς κορυφῆς· αὕτη δ' ἐπίπεδος μὲν πολὺ μέρος ἐστίν, ἄκαρπος δ' ὅλη, ἐκ δὲ τῆς ὄψεως τεφρώδης, καὶ κοιλάδας φαίνει σηραγγώδεις πετρῶν αἰθαλωδῶν κατὰ τὴν χρόαν, ὡς ἂν ἐκβεβρωμένων ὑπὸ πυρός, ὡς τεκμαίροιτ' ἄν τις τὸ χωρίον τοῦτο καίεσθαι πρότερον καὶ ἔχειν κρατῆρας πυρός, σβεσθῆναι δ' ἐπὶ λιπούσης τῆς ὕλης. τάχα δὲ καὶ τῆς εὐκαρπίας τῆς κύκλῳ τοῦτ' αἴτιον, ὥσπερ ἐν τῇ Κατάνῃ, φασί, τὸ κατατεφρωθὲν μέρος ἐκ τῆς σποδοῦ τῆς ἀνενεχθείσης ὑπὸ τοῦ Αἰτναίου πυρὸς εὐάμπελον τὴν γῆν ἐποίησεν.

eruption was such an important one, not only from the appalling results which followed, but also from its having been the first of the long series of eruptions which have interested and astonished the world during the historic period, the letters containing the account by Pliny the Younger, who was an eye-witness of the awful scene, and whose uncle was one of those who perished by the catastrophe, are given in the Appendix to this work.

It will be remarked that in Pliny's narrative there is no mention of lava having been seen, and this is quite in accordance with the results of modern observation, which has not detected any bed of lava of the same age as the lapilli which overwhelmed Pompeii. It appears, therefore, that this great eruption was one of fragmentary ejectamenta, and that the melted rock which is given forth in modern times during eruptions was then entirely wanting.

An examination of the material covering the ruins of the ancient city will show that the bulk of the Vesuvian ejectamenta which obscured the light of the sun as completely as Pliny describes, and burying the city of Pompeii destroyed it for ever, was light, grey, pumiceous lapilli, evidently quite dry at the time of its fall, since it is now in a perfectly loose and uncompacted state. The present condition of the numerous frescoes with which the houses of the wealthy inhabitants were adorned affords further evidence of this dryness, the

colours of these, in many cases, beautiful decorations being comparatively fresh and uninjured.

It is probable, however, that at a later period of the same eruption, ashes and lapilli mingled with water condensed from the volcanic steam, formed a flood of mud, since the city of Herculaneum is buried beneath a mass of consolidated tuff, and not as Pompeii, simply covered with loose ejectamenta. This great eruption left the mountain with only half of the walls of the ancient crater remaining, the sides on the south and west having been almost completely destroyed.

It was now that the foundations of the modern cone of Vesuvius began to be laid, and thus was commenced the building up of the present great central feature of the whole mountain mass, the Great Cone. Successive ejections of fragmentary matter accumulated material in the central cavity of the old crater, and so formed what would be an inverted cone, then a double cone, until at length a large eruptive cone was built up, which, continuing to increase by the aggregation of the ejecta of successive eruptions, ultimately attained an elevation exceeding that of the rim of the old great crater, and thus has been produced the double-peaked mountain of the present century. There was, however, left on the southern and western sides remnants of the wall of the old crater, and one, even to the present time, is seen as a protuberance on the side of the mountain, and forms the elevation at the

edge of the desert area named, as previously stated, the Pedimentina, while another constitutes the ridge on which stands Prof. Palmieri's observatory.

It may well be imagined that what has been called the Plinian eruption, with its horrors and devastating consequences, produced such a deep and lasting impression that for a long period ordinary displays of eruptive energy would appear to be comparatively insignificant and unworthy of special record; and indeed Dion Cassius, writing in the third century, gives expression to this view. It is to be remembered also that the depth of the crateral cavity left after the great eruption would be so profound that much eruptive phenomena might occur that would not be visible, or at least conspicuous, above the summit of the surrounding walls. Thus frequent eruptive activity may have occurred in the early centuries of the Christian era without being recorded, and consequently the history of Vesuvius must be regarded as being but an incomplete one.

The earliest renewed outbreak of which some account is extant was that of the year 203, which was described by Dion Cassius as a great conflagration. In the year 472, however, there was an eruption which must have been of paroxysmal violence, since it destroyed the villages that had been built over the buried cities of Herculaneum and Pompeii, and ejected ashes to so great a

distance that it is said some fell as far from the mountain as Constantinople.

During a period of nearly six hundred years following, only three eruptions are recorded. These were in the years 512, 685, and 993. The first is recorded in Procopius' "History of the Gothic Wars," the translation of which by Sir Henry Holcroft in 1653 gives the following quaint passage: "At the top is a deep cave, seeming to reach to the bottom of the mountain ; and if you peep in, you may see fire, which ordinarily keeps in, not troubling the people. But when the mountain bellowes like an ox, soon after it casts out far away a large quantity of cynders, which catching a man upon the way, he hath no means to save his life."

The eruption of 1036 is important geologically, since the first lava-flows of the Historic Period appear to have been emitted at this time, and to have been so considerable as to have reached the sea.

There are reports of eruptions in 1049, 1138, and 1139 ; but after the last-named date, for about five hundred years, there does not seem to have been any important outbreak. But during this period of Vesuvian quiescence, when, according to Sir William Hamilton, "the top of the mountain began to lose all signs of fire," volcanic action was very violent in the neighbouring districts. Several eruptions of Etna are recorded ; the Solfatara as well as the volcanic island of Ischia poured

forth streams of lava of great volume; and the northern as well as the southern portions of Italy were convulsed by earthquakes. It was, too, during this season of the comparative repose of Vesuvius that occurred the extraordinary volcanic phenomenon of 1538, for it was in this year that Monte Nuovo was thrown up.

For a long time previous to the great eruption of 1631, the crater of Vesuvius contained so much vegetation that it became the resort of wild boars, and cattle grazed on the plain at the bottom. "Within the crater," writes Bracini, "was a narrow passage, through which by a winding path you could descend about a mile amongst rocks and stones, till you came to another more spacious plain covered with ashes. In this plain were three little pools placed in a triangular form—one, towards the east, of hot water, corrosive and bitter beyond measure; another, towards the west, of water salter than that of the sea; the third of hot water, that had no particular taste."

At the end of the year 1631 commenced one of the most important of the modern eruptions of the Campanian volcano. In this year the great crater became filled with volcanic matter level with the brim, and on the 16th December a column of ashes mingled with vapour was ejected from the cone, while great quantities of stones were discharged and volcanic lightning flashed. After this no less than seven streams of lava descended the mountain, and

an earthquake caused the sea to recede for half a mile. This terrific eruption resulted in a most awful destruction of human life, no fewer than 18,000 persons having, it is said, perished during its continuance. The villages of Torre del Greco, Resina, Granatello, and Portici were either wholly or partially destroyed ; and a large space of land was inundated by the torrents of rain produced by the condensation of the immense volumes of vapour discharged from the mountain. The lava emitted during this eruption forms a considerable portion of the substratum under the road between Resina and Torre del Annunziata. It may be seen at many points along the high-road, as well as by the side of the railway running between the road and the sea, and it is quarried for road material close to the sea-shore at Torre Scassata. It is this lava which covers the tuff under which Herculaneum lies buried, and which has rendered the excavations for the exploration of the ruins of that ancient city so costly and so difficult ; while upon it stand the modern towns of Resina and Torre del Greco ; and the beautiful gardens of the royal palace of Portici cover a portion of its surface.

An eruption, remarkable for having thrown up a perpendicular stream of lava, occurred in the year 1676 ; and during the next twenty years various eruptions took place, which much modified the shape of the mountain. At this period it appears that the

highest point of Somma was 1,200 feet higher than the summit of the eruptive cone.

A stream of lava four miles in length, and upwards of 100 yards wide, where broadest, flowed from the mountain in 1694, and ran in the direction of San Giorgio a Cremano ; and one, two years afterwards, towards Torre del Greco.

During the next hundred years the volcano was in very frequent activity ; and several of the eruptions which occurred at this period are deserving of notice, on account of the remarkable nature of the phenomena witnessed during their continuance.

One of the early eruptions of the eighteenth century, that of 1707, was a very violent one ; and is noticeable for the immense quantity of ashes then discharged by the volcano. It is stated that the cloud of ashes over Naples was dense enough to involve the city in such complete darkness that nothing could be seen in the streets. The shrieks of women, we are told, filled the air; and the churches were crowded with people, while the relics of S. Januarius were carried in procession. The wind, however, changing, and the ashes being carried in another direction, the alarm of the people subsided.

The eruption of 1737 poured forth a stream of lava no less than a mile in width, and containing upwards of 300,000,000 cubic feet. Sir Charles Lyell speaks of the lava of this eruption in his " Principles of Geology," in which he mentions that it may be

seen near Torre del Greco, where it displays an incipient columnar structure. This section of lava-rock is immediately outside the town of Torre del Greco, on the road to Torre del Annunziata, and may there be seen presenting a surface twelve or fifteen feet in height. The great stream flowed from the side of the mountain, but at the same time another was emitted from the crater on the summit, which divided into branches taking opposite directions, and causing a great destruction of property. A large quantity of ashes was also ejected, and this ash falling on the trees in the surrounding district, especially in the neighbourhood of Ottajano, also occasioned great damage. A curious mephitic vapour was emitted by the mountain after the eruption, which destroyed life.

In 1751, during an eruption which again produced a great flow of lava, the central cone sank, leaving a hollow of great depth and width.

Much lava was discharged in 1754, the stream this year taking the direction of Bosco del Mauro and Bosco tre Case.

There was a remarkable outbreak in the year 1760. The lava of this eruption flowed from new cones that were formed, not on the summit of the mountain, but on its side, not far distant from the convent of the Camaldoli. Great columns of smoke, and immense quantities of ashes, were also given forth by these new cones, which may still be seen.

The great eruptions of 1766, 1767, and 1770 are

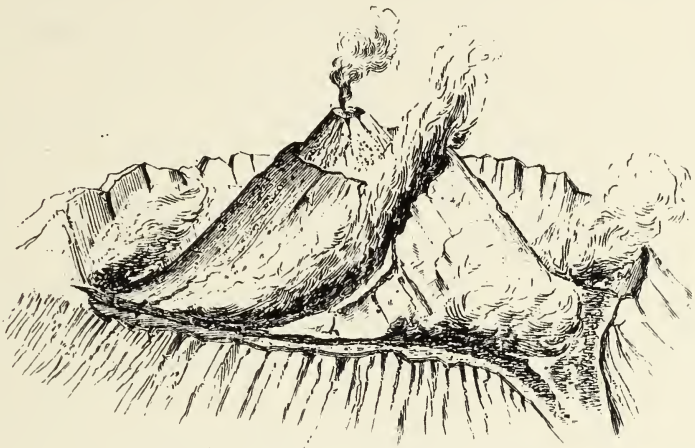

FIG.1. THE CRATER OF VESUVIUS IN 1756.
(AFTER HAMILTON)

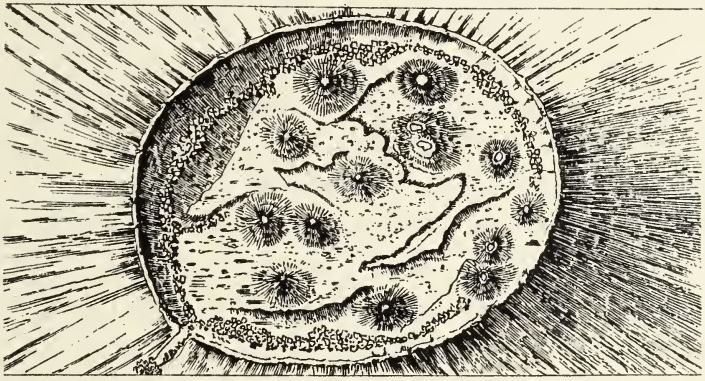

FIG.2. THE CRATER OF VESUVIUS IN 1805.
(AFTER DUCA DELLA TORRE)

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graphically described by Sir William Hamilton in his letters to the Royal Society, an extract from which, having reference to the eruption of 1767, may be here given.

"I observed on my way to Naples, which was in less than two hours after I had left the mountain, that the lava had actually covered three miles of the very road through which we had retreated. It is astonishing that it should have run so fast; as I have since seen, that the river of lava, in the Atrio di Cavallo, was 60 and 70 feet deep, and in some places near two miles broad. When his Sicilian Majesty quitted Portici, the noise was greatly increased; and the concussion of the air from the explosions was so violent, that in the king's palace doors and windows were forced open, and even one door there, which was locked, was nevertheless burst open. At Naples, the same night, many windows and doors flew open; in my house, which is not on the side of the town next Vesuvius, I tried the experiment of unbolting my windows, when they flew open upon every explosion of the mountain. Besides these explosions, which were very frequent, there was a continued subterraneous and violent rumbling noise, which lasted this night about five hours. I have imagined that this extraordinary noise might be owing to the lava in the bowels of the mountain having met with a deposition of rain-water; and that the conflict between the fire and the water may, in some measure, account for so extraordinary a crackling and hissing

noise. Padre Torre, who has wrote so much and so well upon the subject of Mount Vesuvius, is also of my opinion. And indeed it is natural to imagine that there may be rain-water lodged in many of the caverns of the mountain; as in the great eruption of Mount Vesuvius in 1631, it is well attested that several towns, among which Portici and Torre del Greco, were destroyed by a torrent of boiling water having burst out of the mountain with the lava, by which thousands of lives were lost. About four years ago, Mount Etna in Sicily threw up hot water also during an eruption.

"The confusion at Naples this night (19th October, 1767) cannot be described; his Sicilian Majesty's hasty retreat from Portici added to the alarm; all the churches were opened and filled; the streets were thronged with processions of saints: but I shall avoid entering upon a description of the various ceremonies that were performed in this capital to quell the fury of the turbulent mountain.

"Tuesday, the 20th, it was impossible to judge of the situation of Vesuvius, on account of the smoke and ashes, which covered it entirely, and spread over Naples also, the sun appearing as through a thick London fog, or a smoked glass; small ashes fell all this day at Naples. The lavas on both sides of the mountain ran violently; but there was little or no noise till about nine o'clock at night, when the same uncommon rumbling began again, accompanied with explosions as before, which lasted about four hours:

it seemed as if the mountain would split in pieces. * * * * * During the confusion of this night, the prisoners in the public jail attempted to escape, having wounded the jailer, but were prevented by the troops. The mob also set fire to the Cardinal Archbishop's gate, because he refused to bring out the relics of Saint Januarius.

"Wednesday, 21st, was more quiet than the preceding days, though the lavas ran briskly. Portici was once in some danger, had not the lava taken a different course when it was only a mile and a half from it; towards night the lava slackened.

"Thursday, 22nd, about ten of the clock in the morning, the same thundering noise occurred again, but with more violence than the preceding days; the oldest men declared they had never heard the like; and, indeed, it was very alarming; we were in expectation every moment of some dire calamity. The ashes, or rather small cinders, showered down so fast, that the people in the streets were obliged to use umbrellas, or flap their hats, these ashes being very offensive to the eyes. The tops of the houses and the balconies were covered above an inch thick with these cinders. Ships at sea, twenty leagues from Naples, were also covered with them, to the great astonishment of the sailors. In the midst of these horrors, the mob, growing tumultuous and impatient, obliged the Cardinal to bring out the head of Saint Januarius, and go with it in procession to the Ponte Maddalena, at the extremity of Naples, towards

Vesuvius; and it is well attested here, that the eruption ceased the moment the Saint came in sight of the mountain; it is true, the noise ceased about that time, after having lasted five hours, as it had done the preceding days."

An eruption of no great importance occurred in 1776; but three years after, in 1779, one of very great violence and remarkable character took place. Several great streams of lava were emitted on this occasion, and the showers of ashes were sufficiently dense to produce darkness in the vicinity of the mountain. Vapours most destructive both to animal and vegetable life were given off in profusion. But perhaps the most extraordinary feature of this terrible outbreak was the rising of a column of liquid fire, as it is described, to a height which Sir William Hamilton considered to be three times that of the mountain. After this a black cloud, emitting flashes of lightning, advanced from over Vesuvius towards Naples, spreading consternation and terror among the inhabitants of the city. The theatres were closed, and the relics of San Januarius again carried in procession. The destruction to property caused by this eruption was very great, especially to the vegetation of the district.

Terrible, however, as was the eruption of 1779, it was exceeded by the appalling outbreak of 1793-4, which lasted from the February of one year until the Midsummer of the next. This eruption produced no less than fifteen mouths, which emitted as

many separate streams of lava; and these uniting formed one vast body of liquid fire, which flowed steadily on towards the sea, cutting in two the town of Torre del Greco, where it was from twelve to forty feet thick, and actually advancing into the sea to a distance of 362 feet, and presenting a face 1,127 feet broad. It was calculated by Breislak that the whole mass contained no less than 46,098,766 cubic feet of lava. The sea was even in a boiling state at a distance of 100 yards from the lava. This eruption, as has been the case with the great eruptions generally, was preceded by a falling of the water in the wells of the neighbourhood.

From this time until 1822 the several eruptions that occurred were not of a very remarkable character; but on the 22nd of October of that year commenced one which must by no means be passed over. On the day following that date, the top of the cone fell in, and this was succeeded by the emission of a stream of lava nearly a mile in width. So great, too, was the quantity of ashes and cinders ejected, that the country as far as Amalfi, on the Gulf of Salerno, was overshadowed with darkness, and the road between Resina and Torre del Annunziata was blocked up with the fallen ejectamenta. This eruption was remarkable also for the unusually large amount of vapour which issued from the volcano. The vapour condensed into rain; and this was so great in quantity that some districts were inundated. The crater was greatly altered by this

eruption, having been by it much increased in circumference and in depth, and the height of the cone correspondingly diminished. The summit was after this eruption estimated to be not more than 3,400 feet above the level of the sea, 600 feet of the top of the cone having been blown away, while the depth of the crater was stated by Mr. Babbage to be 938 feet.

The eruption of 1828 produced a small cone in the centre of the large crater formed by the great outbreak of 1822; and in 1831 the summit of the new cone was higher than the edge of the great crater, which had become filled with the ejectamenta of the volcano. The whole of this new cone was, however, destroyed by the eruption of 1834, during which the volcano poured out a most copious stream of lava, causing the almost total destruction of the village of Caposecco, only four houses out of five hundred remaining. The river of lava which destroyed this village was nine miles long; and so great was its heat, that it is said to have been felt at Sorrento, a distance of nearly ten miles. One stream of the lava taking the direction of Pompeii, that ancient city was threatened with another interment.

Since 1834 the eruptions have been very frequent, and have been especially noticeable from the fact that they have produced lavas containing a greater quantity of leucite than is to be found in the lavas of the previous eruptions of the historic period, and therefore more like the ancient lavas of Monte

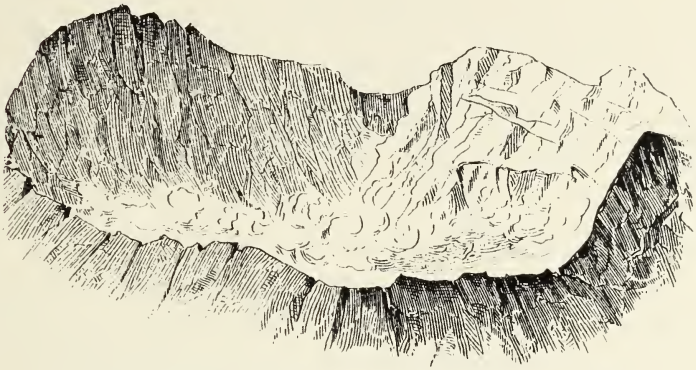

FIG 1 THE CRATER OF VESUVIUS AFTER THE GREAT ERUPTION OF 1822
(AFTER SCROPE)

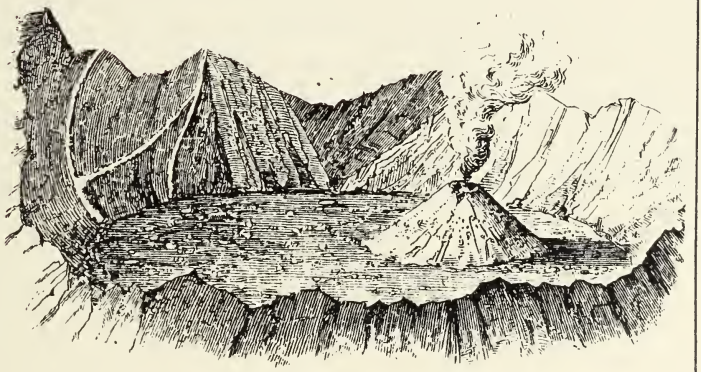

FIG 2. THE CRATER OF VESUVIUS IN 1828.
(AFTER MONTICELLI)

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Somma, in which this mineral is very abundant. We are told by Professor Pilla that crystals of leucite as large as nuts were not only found imbedded in the lava of 1845, but were thrown out of the crater of the volcano in that year. This fact is of value, as showing that these crystals of leucite were formed within the vent previous to the eruption.

The lava of 1850 formed a flowing mass no less than a mile and a half broad, which steadily advanced towards Bosco Reale and the south of Ottajano, consuming the woods of large trees that lay in its way, and threatening with total destruction the populous villages lying on that side of the mountain.

Thus at quite the end of the first half of this century there was another of those emissions of lava which had been so frequent during almost the whole of the preceding hundred years, a century of activity of lava-producing power and eruptive energy, from 1751 to 1850, perhaps unsurpassed by Vesuvius in any previous equal period of time.

CHAPTER V.

HISTORY: 1851—1868.

Eruptions of 1855 and 1861 — Eruption of 1867-68—Aspect of the Surface of Vesuvius during the Eruption of 1868—Ascent to the Summit — Lava-Flows—The Cone—The Ring Terrace—The Eruptive Cone and Crater—The Eruptive Phenomena seen from the Crater Rim.

SUBSEQUENT to the eruption of 1850, normal inactivity prevailed for upwards of four years, but the frequent activity of Vesuvius during the first half of the present century did not exhaust the eruptive energy of the volcano for any more lengthened period, since the year 1855 witnessed an eruption of more than usual violence. This eruption produced lava which retained its fluidity for such an unusually great length of time that it flowed in a comparatively narrow stream almost to the suburbs of Naples, running between the villages of Massa di Somma and San Sebastiano, and reaching Cercola. This stream flowed from the side of the cone above the Atrio del Cavallo, into which it poured; and following the course of the Fosso della Vetrana and the Fosso Faraone, it divided into two branches, one of which extended, as above stated, to Cercola, while the other took the direction of San Jorio, and almost reached that village. The lava penetrating so far into the cultivated region at the base of

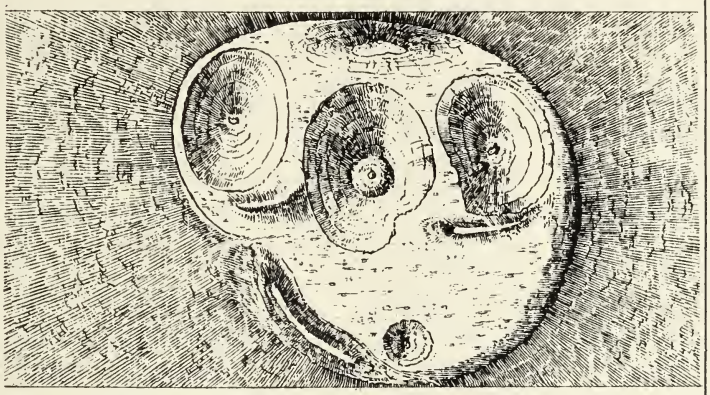

FIG 1. THE CRATER OF VESUVIUS IN 1856.
(AFTER BORNEMANN)

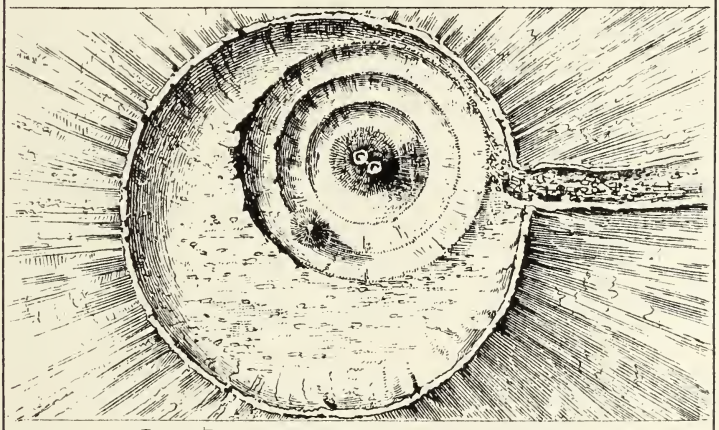

FIG 2. THE CRATER OF VESUVIUS IN 1883.
(AFTER LAVIS)

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Vesuvius, caused a most deplorable destruction of property, and greatly terrified the inhabitants of the district, who feared it would destroy Portici, and perhaps reach even to the city of Naples.

Three years afterwards, another eruption occurred; and it was the lava of 1858 that formed a very conspicuous feature on the side of the mountain for many years, covering as it did a large area crossed by the usual route to the summit from Resina. This lava was emitted in copious streams from new craters, which opened in the Piano and flowed into the Fosso Grande at the base of the Crocella ridge.

Another great flow of lava occurred in 1861, but so low down on the mountain-side did the mouth open from which the stream poured, that it was not more than a mile distant from the town of Torre del Greco. Besides the opening from which the lava was emitted, ten other craters were formed, that ejected great quantities of ashes. The neighbourhood, as well as the town of Torre del Greco itself, again suffered greatly from this eruption, which caused the ground to be rent with fissures, and a large area to be covered with a fiery flood that threatened to at length completely destroy that much-enduring city.

Professor Palmieri reported that after the year 1861, there was a large and deep crater with a few fumaroles of moderate temperature, and often evolving only pure carbonic acid gas. Occasional slight ejections, however, gradually built up a small

cone inside the great crater. But general, if not complete quiescence reigned from the termination of the eruption of the year 1861 until towards the end of 1867, when the eruption of that and the following year commenced.

The eruption of 1867-8 was a long-continued one of great irregularity and variation of volcanic force and energy, sometimes becoming so violent as almost to rise to the dignity of what is commonly called a "great eruption;" at others, and for a considerable time together, falling away in intensity, and sometimes even displaying so little violence that the volcano almost reached a normal state of repose, and on several occasions it was confidently but prematurely predicted that the eruption was terminating.

For a fortnight previous to the night of November 12th, 1867, the Vesuvian seismograph by its agitation, increasing until the outbreak, clearly indicated that volcanic force was acting in the interior of the mountain. On the morning of the 13th, at half-past twelve, lava appeared from the new cone which was shortly afterwards ruptured, and from four or five openings the molten matter issued, and flowed into the hollow of the great crater. It is stated that the rupture of the cone was produced by an elevatory force that uplifted masses of compact lava into vertical prisms. This cone just overtopping the great crater rim, continued to discharge lava until there was a sufficient weight

of it to break down a portion of the wall of the great crater, when it poured over on one side towards Ottajano and on another towards Massa di Somma, in this case forming a stream upwards of 10 yards wide and soon reaching 1,000 yards from the summit. The ejections consisted chiefly of small partly cooled masses locally called "schiuma," which were thrown about 300 feet high above the top of the eruptive cone, but solid masses of great weight, some half a ton, it is said, were also ejected.

By the 21st of November the eastern flow had increased so much as to form a stream of 40 or 50 feet in width. The new cone now rapidly increased in height and bulk, with a corresponding increase of its crateral opening, until it attained a height of nearly 400 feet, and then filling up completely the old great crater, it produced a ring-like plain around itself, a circular terrace at the level of the rim of the old great crater, which was now no longer in existence. The loose materials of which the new cone was formed soon gave way on its west side to allow of the escape of lava from the small new crater, and this lava then flowed down the new cone over the terrace and down the side of the great cone. It soon covered a large area at the base of the great cone, spreading out on the region of La Plaine, between the Crocella and the Piano del Ginestre.

Prof. Palmieri has put it on record that he observed two maxima and two minima daily in the

flow of the lava, and that the maxima were half an hour later each day, and, moreover, that the eruption strengthened at full and new moon and weakened at the quarters.

In the early part of December, there was much violence with a great ejection of ashes, scoriæ, and lava, accompanied by loud thunderings and bellowings, called "beoti," heard at Capri twenty miles away, and violent earth movements that caused so much alarm to the inhabitants of the neighbouring towns that hundreds of chests of coral were sent off from Torre del Greco to Naples for safety. During this period, no less than thirteen streams of lava on the cone were counted, and some falling over projecting masses gave the splendid effect of cascades of fire.

The new cone had now meanwhile grown to maturity, and so gave an approximately complete apex to the summit of Vesuvius, and, at the same time, a greater height than ever before during historical times, to the mountain, and, too, a more regular conical outline. In the latter part of December, the lava-flow on the western side of the great cone slackened, leaving but a small stream, the principal issue being then on the eastern side.

On the 3rd of January, 1868, there was a recommencement of the great flow on the western side, and this was so copious as to threaten the Observatory and even Resina and Torre del Greco. The lava flowed in two streams that formed an ellipse.

FIG 1. VESUVIUS AFTER THE GREAT ERUPTION OF 1631.
(AFTER CARAFA)

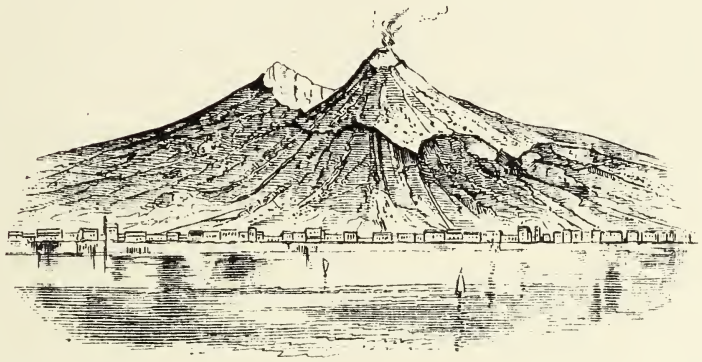


FIG 2. VESUVIUS AFTER THE ERUPTION OF 1868.

LONDON, ROPER & DROWLEY, 11 LUDGATE HILL, E.C.

One advanced in two days from the foot of the great cone to a point near the Observatory, but then stopped, while quite a river of molten rock sixty yards wide reached, on the 12th of January, the Piano del Ginestre, threatening the towns below. On the 15th of January, however, there was a lull, and the lava ceased to flow further. So little, however, were the people of Resina alarmed during this flow, that they met it with bands of music and celebrated the advance of the lava with polkas and marches, for a lava-flow brings many visitors with money to Resina; nor was their confidence in its harmlessness unjustified, as proved by the event.

From the middle of January until the 26th of that month, the pause continued, but on that day the lava again flowed over the summit of the cone, but quite tranquilly, and covered all the upper part of the mountain with liquid fire, affording a grand spectacle from the bay or from Naples, where, on the Strada Santa Brigida, crowds assembled, near to where on this night occurred the fatal fall of the tufa cliff at Santa Lucia.

During the early part of February, the action was much diminished and intermittent, thereby affording an opportunity for the deposition of sublimates, the chemical productions of the volcano. Thus it was that salts of lead and copper, chiefly chlorides, as well as chloride of sodium, were in great abundance on the surface, especially about the fumaroles. Palmieri says, on February 6th, the

fumarole are again decorated with copious white, yellow, and green sublimates, amongst which, besides common salt, are found copper and lead.

A curious phenomenon was produced by the diminished flow of lava which, as it descended the great cone, had its surface cooled and solidified, while remaining fluid in the mass. The result was the formation of a tunnel or great tube of solid black rock on the side of the cone, with the hot fluid lava flowing out at the bottom, and giving the appearance of issuing from the base of the cone. There was still a considerable flow, and on the 17th of February, five streams fell over ridges producing as many cascades of fire.

There was another diminution with a brief revival on the 3rd of March, when the eruption was unusually splendid, and again a lull until the 8th of March, when violent activity recommenced, and ejectamenta were fired up to 1,600 feet.

On the 11th, a great fissure opened on the Pompeiian side from which issued "rough slaggy" lava, while on the Naples side the flow was filling the valley at the base of the Crocella. Volcanic ash fell very abundantly round the mountain, so that Resina, Naples, and even Posillipo ten miles distant, suffered much from this black powder. It is estimated that on the night of the 12th of March, the ashes covered an area of six square kilometres to the extent of 14 kilogrammes to the square metre, which would give a fall of ash of 84 millions of

kilogrammes in one night in the immediate neighbourhood of the mountain, and on the 13th and 14th the ash was carried as far as Sicily and Gaeta. On the 21st, 22nd, 26th, and 27th March, great activity prevailed, and much lava flowed, producing splendid effects as seen from Naples.

During the summer there was a great diminution of activity, but the volcano was far from quiet, smoke and ashes being constantly ejected, and on the 22nd of June the shocks were so violent that people passed the night in the open air, while on the 1st of July the ejections were so great that several who ascended the mountain were severely injured. A renewal of lava-flow occurred on the 8th of October, and the amount increasing on the 10th of November, the cultivated area was again threatened, but the 26th of that month witnessed the last lava of this eruption, one which had been continuous from the 12th of November of the previous year, and therefore having had a duration of more than twelve months.

The appearances and phenomena presented by the volcano during an eruption, may perhaps be best gathered from an account of an ascent to the summit I was able to make during a somewhat violent phase of this one in March, 1868.

The observable phenomena are many and varied, and if at times terrific, yet are so interesting and indeed fascinating, that fear or thought of danger is driven away. On the question of danger it may

be admitted, as shown by the preceding record, and still more by the sad fatality of 1872, that a considerable amount of danger to observers undoubtedly exists. But it is worthy of remark that although the spirit of inquiry naturally induces scientific observers to make repeated explorations and to make them as complete as possible, yet the fatalities that occur are almost always those which befall tourists or others most probably on a volcano while active for the first time in their lives, leading to the conclusion that a little knowledge of volcanic action is a great safeguard.

Though the ascent from Pompeii has some recommendations, that from Resina is by far the most interesting, and gives the best and clearest understanding of the topography, as well as of the structure of the mountain. It is not unusual for visitors to ascend as far as the Hermitage on saddle, as there is a practicable bridle path, and much fatigue is doubtless thereby prevented, but an ascent on foot ought always to be made by those who wish to observe the phenomena presented by the volcano with the greatest advantage. An ascent on foot indeed must be made if any exploration or anything more than a mere visit to the mountain by the usual route, be desired, and it is a waste of opportunity for any one to go to Vesuvius with its many remarkable features, without attempting more than an ordinary ascent.

A stout pole or alpenstock, thick-soled boots, a

pocket compass, a clinometer, a map, and a geological hammer, with paper and bag for specimens, will be found very useful, and yet not forming an encumbering burden. Guides, although not necessary to show the route, which is clear enough, are very useful both to parties and to individuals, for many purposes, and especially as guards against the importunate solicitations of other guides who will be met with on the mountain-side.

The ascent commences at once from the main road by a narrow lane between the houses, and very soon a position is gained from which a less confined view is obtained. The inclination of the path is not at all steep, but the pavement is somewhat rough, and it is only the heat, which is often great at Resina, that causes any difficulty. Once clear of the houses, the foliage of the vineyards and gardens through which the path now passes is refreshing to the eye, and the cooler air, the more and more extensive prospect, with the sparkling waters of the bay dotted with the lateen-sails of fishing-boats, refresh the spirit. From time to time a table is seen at the gate of a garden where wine and fruit may be bought, and this is the wine and fruit for which the slopes of Vesuvius are so famous, and both may be purchased where produced, at a very cheap rate. The belt or zone of cultivated land is, as has been previously stated, on a slope of about 10° or 12° and about two miles broad, giving a walk sufficiently long for a protracted

enjoyment of the luxuriance and beauty seen on all sides.

And then there is a change from a garden to a desert, for as soon as the cultivated zone is crossed, a vast expanse of undecomposed black rock is reached. In place of beautiful gardens in which the orange, the lemon, the almond, the fig, and the vine flourish in perfection, and in which roses and camellias bloom in profusion, there extends around, a black sterile waste without a trace of verdure of any kind, and displaying only huge folds, waves, and unshapely masses of rough dark-coloured lava-rock.

So totally unlike anything else is it, that there is some difficulty in conveying to those who have not seen a volcano, a clear idea of the extraordinary aspect of the part of the mountain covered by recent lava-flows; but its appearance may perhaps be to some extent understood, if it can be imagined that a stormy sea of boiling pitch has been suddenly cooled so as to retain in a solid form all the roughness, angularity, and irregularity which the surface possessed while liquid. In some places, indeed, the lava has assumed the appearance of great coils of thick black ropes, but in others, sharp and rugged ridges, like the crests of breakers, rise, and in others, again, huge blisters stud the surface, while large areas are covered as it were with smoother rolling waves. This is the region of desolation, the Desert Platform, of about a mile in breadth, diminishing to a

quarter of a mile in the Atrio del Cavallo, which extends around the mountain at the base of the Great Cone and inside the ridge of Somma, both of which rise from it. Here were to be found those smaller lava streams which allow of a close inspection without danger. They are marked, as seen from a distance, by a line of steam which arises continuously from them, but on being approached, they are found to be glowing molten rock, not white-hot, yet more than red-hot, being, in fact, yellow-hot, if such a term may be used.

They flow rather on elevations than in depressions, but elevations made by themselves, for they are indeed embankments formed by their own cooled surface portions, which, falling over the end of the slowly-flowing lava, form a bed in advance of the stream, which, with the diminishing rapidity of the increasingly viscid mass, receives more rapid additions to its bulk, and this being on a slope, the bed thus produced increases in height as the ridge advances, and so becomes more nearly level, and this gradual diminution of inclination again lessens the rapidity of the flow, and facilitates cooling and solidification. Thus it is that small and even rather large streams are prevented reaching the cultivated zone, and so inspire no terror to the owners of the gardens and vineyards near. Indeed, work was going on in the most assured way possible, in a garden immediately in front of, and at no great distance from the end of such a stream, the

proprietor evidently feeling quite sure that the flow would never reach his boundary wall.

These small streams were moving over this part of the mountain, which has little slope, at about 300 yards per hour; but it will be readily understood that this is no measure of the rate of progression of larger, and therefore more fluid, because hotter, flows, and no indication whatever of the rapidity with which lava fresh from the volcanic tube descends the steep slope of the cone.

Some lavas, too, are more fluid than others, on account of a somewhat different composition, as was the lava of the eruption of 1855, which was especially mobile, its great liquidity being attributed to its containing the mineral Cotunnite, a chloride of lead. Statements of the rate at which lava has been found to flow are therefore of little value if the position, circumstances, and conditions of the flow are not at the same time stated.

Solidification goes on very rapidly on the surface of lava when the mass is not great, and hence it is that on small streams there is a very abundant production of *scoriæ* or flattish masses with a vesicular structure. The vesicular structure of scoriæ is due to the absence of pressure, which allows of the formation of vesicles by the gaseous emanations from the lava. Thus it is that small lava-flows produce abundance of scoriæ, and great lava-flows produce masses of compact rock. An ordinary lava-flow will consequently ultimately form

a bed of compact rock reposing on one of scoriæ, and covered by another layer of scoriæ, the underlying scoriæ being that which has been pushed over the end of the stream while flowing, and so has formed its bed, and the overlying scoriæ being that which has formed on the surface immediately before, and at the time the lava ceased to flow. Such masses of compact lava-rock with scoriaceous bottom and top beds, the result of volcanic action in far-distant periods, are often met with in various geological formations.

The lava of these streams seems to be of greater consistence than honey, small stones thrown upon it not sinking into the mass, but remaining on its surface, and it readily lends itself to being moulded by iron moulds into medallions.

The heat given off is considerable, but so much less on the windward side, that no inconvenience is experienced in standing by the side of the flow and lighting the end of a wooden stick by the hot lava. Steam seems to be almost all that is given off from the fluid mass, as the immediately adjacent air is not at all offensive.

The general surface of the Piano was very difficult to traverse, the ridges being high, hard, and sharp. In some places, the crests of the masses of lava were breast high, in others less so, but in all great care and no inconsiderable labour was required to traverse a large part of this sea of solidified lava.

In some places, too, the rough hard surface was very hot, so much so that boots were scorched, and cracks at places showed red-hot lava at but a little distance below. A large area, overlooked by the Crocella, was recently solidified lava, with hot lava immediately underneath, so that the atmosphere above was visibly affected. A little earlier all this area was covered with fluid lava that spread out at the bottom of the cone like a sea of fire. The flow from the base of the great cone issued with remarkable tranquillity and quietness, like molten iron from a furnace, from the lower mouth of the tunnel the lava itself had formed upon the slope.

It is remarkable what a small amount of solid lava-rock is to be seen on the sides of the great cone, notwithstanding the large number of flows that have solidified on its slopes. The amount of scoriæ that is found on the surface of solidifying lava-flows and the great quantity of scoriæ, bombs, and ashes, that falls on the side of the cone and covers and conceals any solid lava-rock that may have there been formed, renders the surface of the Great Cone a slope of loose incoherent material. A partial exception to this rule was the remarkable tube of lava-rock from top to bottom of the slope, standing out, though not conspicuously, from the normal surface of scoriæ.

Volcanic ash, which, when mingled with the ascending steam from the crater, constitutes the "smoke" of the volcano, falls chiefly on the lee side,

or that in the direction of the wind, but when there is little wind, it is more equally distributed with a heavier fall near to the ejecting orifice.

On the hill of the Crocella to the left, the light-coloured, modern, and handsome Observatory, with its straight architectural lines, stands clearly against the blue sky, conspicuous in its great contrast to the dark weird waste around, which is completely overlooked from the terrace. The top of the stone balustrade in front was covered with the black ash, and whenever this was swept off, the surface of the stone was quickly re-covered.

Those having mules or horses must leave them at the Hermitage of San Salvatore, and prepare to ascend the Great Cone on foot if no eruption forbids it, or now by the rope tramway or "Funicular Railway," as it is called, which was opened in 1880. This latter method certainly saves labour and time, but it so far detracts from that complete exploration of the mountain which can only be made by a considerable expenditure of both labour and time. An old mode of ascent was by means of a chair on poles, carried by porters up the slope of the cone in such a way that the occupant of the chair was always in a vertical position.

The Atrio del Cavallo at the base of the great cone has a most gloomy and desolate aspect. It is truly a "valley of rocks" without the slightest relief from verdure or vegetation of any kind. On the right hand the steep and rugged side of the

great cone rises, and on the left the still more steep and still more rugged escarpment of Monte Somma, while the bottom is paved with irregular masses of bare, dark lava from one side to the other. Rain storms appear to wash out all loose material from the bottom of the Atrio, leaving a solid floor composed of the lavas of the most recent flows on this side the cone, which spread over and across the approximately horizontal bottom. Somma's precipitous wall-like cliffs show a rugged surface from the frequent alternation of beds of scoria and sheets of lava, and the frequent projection of the vertical or highly inclined basaltic dykes which are so numerous in this ancient crater remnant, while the uppermost edge of the enormous ridge shows a jagged and serrated ridge with sharp points against the sky.

The laborious ascent of the Great Cone occupies a long time, but the frequent necessary pauses enable the opposite cliffs of Somma and their wonderful and instructive structure to be well seen and well impressed on the memory, so that the time is by no means wasted, while, during the progress of an eruption, the fall of bombs and scoria sometimes too near to be altogether agreeable, and the explosions becoming louder and louder, render the ascent by no means devoid of excitement. The elevation attained was now upwards of 3,000 feet above the level of the sea, and as we were on the north-western side of the cone a more bracing

air and a cool shade counteracted the fatiguing effects of the laborious climb.

At length a rounded surface indicated the summit of the long slope, and in a few yards more an almost flat plateau, or rather terrace, was reached. This was the circular terrace around the new cone, and at the summit of the Great Cone, the infilling in fact of the great crater by the ejectamenta of the eruption in progress. But how beautiful was the surface! Orange, red, bright blue, and white, on all sides. Light fumes were rising, but only sufficient to slightly veil, not to obscure, the "Persian pattern" of this carpet of the throne of Vulcan. This chromatic variegation of the surface was due to the formation of salts of lead, and copper, and iron, as well as of chloride of sodium or common salt, which was rapidly going on over the surface of the ash-covered scoriæ, and hydrochloric acid gas was being evolved at the same time, with perhaps hydrogen and sulphurous acid gas intermingled. Some specimens of the surface accumulations here were collected, and these even now, after the lapse of twenty years, give off very perceptibly free chlorine, though it is right to state they have been preserved in stoppered bottles that have, however, been many times opened.

The terrace was perhaps 20 yards across, with a slope very slightly inclined towards the exterior edge, and from it arose the new cone with the actual eruptive crater. Explosions, each with a

tremendous roar and discharge, followed each other, and the cinders and scoriæ were being ejected to a great height. The windward side of the new cone was the only one approachable, as the fumes were blown over to the other side, but from this position the firing out of the ejectamenta was seen perfectly, the distance to the edge of the crater not being more than a hundred yards.

Prof. Phillips states (but not from his own observation) that the height of the new cone in November, 1867, was 392 feet, but as the crateral hollow around it was not then filled up he may have intended this as the height from the then base considerably below the level of the rim of the old crater; or the ring terrace, the new and more elevated base of the new cone may have been considerably raised above the level of the old crateral rim by the accumulation of ejectamenta, some falling on to it vertically and some rolling down the slope of the new cone, and resting on the almost level surface at its base. However this may be, the new cone was not at the time of my ascent more than 300 feet above the level of the terrace; and this estimate agrees with Prof. Palmieri's statement that 1296·9 metres, or 4,255 feet, was the extreme height of the summit in 1868, this being 306 feet above the level of the Punta del Palo, which was then covered, but still not much below the surface of the ring terrace.

Higher than the terrace no guide would go, but the phenomena had now become so deeply

interesting and the eruptive crater was so near, that the impulse to gain the summit of the new cone was to me irresistible. Much denser fumes arose from the sides of this cone, but they were kept low and carried closely over the uppermost edge by a strong wind, so that they added no difficulty, and soon I had the long-desired satisfaction of standing, while the volcano was in eruption, on the rim of the eruptive crater, the summit of Mount Vesuvius.

The fumes were dense as high as the waist, but my head was in clear air, and so there was no danger from them except by stumbling and falling down. A complete view of the crater-rim could not be obtained in consequence of these dense fumes obscuring the opposite side, but the depressed lip over which the lava had flowed at an earlier period of the eruption could be clearly seen. The lava had now, however, made a way for itself through the side of the new cone considerably lower down, and this had necessarily reduced the height of the fluid mass in the volcanic tube, and so it was not now visible in the crater, which was filled with the white fumes, chiefly steam, and as it was a bright day the hot lava below indicated its presence only by a faint glow amidst the steam in the crater. Firing out of scoriæ, cinders, and bombs continued, and was intensely fascinating, while the tremors and shakings of the ground which the explosions occasioned still further added to the interest, but, as is elsewhere stated, there was no actual flame (see Flame, chap. ix.).

The explosions, and consequent violent ejections of bombs and fragmentary lava, were not continuous, but followed each other with intervals of a few seconds between. Neither were they of uniform violence, sometimes the projectiles being much more numerous and reaching a much greater elevation than at others.

Yet, fascinating as was the scene, only a very brief stay on the edge of the crater-rim was permissible from the momentary danger of the falling masses, and so the narrow ridge was soon left, though reluctantly, for great was the attractive power of the novelty and sublimity of the wondrous scene.

CHAPTER VI.

HISTORY: 1869—1888.

Repose, 1869-71—Eruption of 1872—Repose, 1873-75—Slight Activity of 1876 and 1877—Activity of 1878 and 1879—Increased Activity of 1880—Strombolean Activity, 1881-83—Scale of Vesuvian Activity—Slight Activity of 1884-88—Continuous Observation and Record of Phenomena.

THE year 1868 was succeeded by a period quiet and uneventful, for following the cessation of the flow of lava in November of that year Vesuvius relapsed into dormancy during both the years 1869 and 1870, except that a slight activity was manifested by the fumaroles at the head of the old fissure, which resulted in the further production of the sulphide of potash and the chlorides and sulphides of copper.

1871.—After being in a quiescent state from November, 1868, to the beginning of this year, during which no lava appears to have issued from the cone and no solid ejecta to have been discharged from the crater, Vesuvius commenced to give indications of renewed activity early in January, 1871, by such tremors as caused greater disturbance of the seismograph, and, at the same time, slight explosions were accompanied by the discharge of a few "incandescent projectiles."

On the 13th of January lava appeared from an opening on the summit of the cone, at first in small

quantity, but with a continuous increase until the beginning of March, but yet the flow was a moderate one, and did not, although the lava was freely mobile, extend far from the base of the cone. A small cone, which had been early produced, subsided in March, but left four masses standing, one of which was compact lava-rock, apparently ejected from an inclined position by the volcanic forces. In the bottom of the small crater a miniature cone, of little more than six feet high, was found emitting smoke and small incandescent scoriæ, but gradually increasing in size, it filled the crater and rose above the brim. Then followed copious streams of lava, which flowed down into the Atrio del Cavallo, then into the Fosso della Vetrana, and extended along the Observatory Hill for upwards of 300 yards, near which solidification stopped further flow.

Prof. Palmieri collected what he called "filiform lapilli," consisting of threads of lava, each containing very small crystals of leucite. This product of highly leucitic lava was in great quantities. Another peculiarity of this lava is the formation of a skin, instead of a covering of fragmentary scoriæ, on the surface of the flows, which, gradually thickening, allowed the fluid lava to flow below it. Thus the flow of lava continued for months to descend covered over, until it reached a part of the mountain below the Canteroni, but soon afterwards its flow was terminated. While exposed, however,

large bubbles formed on its surface, that burst and gave forth "smoke."

A small crater was formed on the edge of the central crater in October, and from it and from openings in the cone small streams of lava flowed until the end of that month, when there were the usual signs of an increase of activity, and on the 3rd and 4th of November large streams of lava flowed down the west side of the cone, and then there was a cessation until the end of the year, but still smoke was given off, and, rendered luminous by the incandescent matter below, continued the alarmed interest of the Neapolitans.

1872.—Activity was resumed quite at the beginning of January in this year, and the crater of the cone of the preceding year poured forth lava, Prof. Palmieri says, "in the most singular and enchanting manner." In February, however, there was a decadence, but at the time of full moon in March a line of fumaroles indicated a fissure on the north-west side, from which lava noiselessly poured into the Atrio del Cavallo, extending quite across its floor to the base of the ridge of Somma. Lava flowed from this fissure for a week, and then ceased, but a new crater with intermittent activity opened between the excentric cone, now 100 feet high, and the central crater. So matters remained until the commencement of the terrific outburst of the latter part of April.

This disastrous eruption, or rather close of a long-continued eruption, also commenced at the time of full moon, on the 23rd of April, when the seismograph was agitated, and the volcanic activity increased. On the next evening grand streams of lava flowed down the cone on various sides, but with the exception of one these ceased on the morning of the 25th, but this one flowed from the base of the great cone, near to the place of issue of the month before. What followed on the succeeding evening is of so tragic a character that it will be best described by Prof. Palmieri himself, who was out on the mountain during the night. The Professor says: "After midnight the Observatory was closed, and my assistant retired to rest. Late and unlucky visitors passed unobserved with an escort of inexperienced guides; at half-past three o'clock in the morning of the 26th they were in the Atrio del Cavallo, whence a copious torrent of lava issued. Two large craters formed at the summit of the mountain, discharging numerous incandescent projectiles with white ashes, and glittering with particles of mica, which frequently recurred. A cloud of smoke enveloped these unfortunates, who were under a hail of burning projectiles, and close to the lava torrent. Some were buried beneath it, and disappeared for ever; two dead bodies were picked up, and eleven grievously injured, one of whom died close to the

Observatory."* Mr. Mallet states that "Eight young medical students perished beneath the lava, with others unknown by name."

The fatal outgush of lava was not from the fissure on the side of the cone, but quite at the bottom, in the Atrio del Cavallo. In the fissure on the cone itself an elongated mound was formed, but this accumulation had no similarity to a cone.

At the same time a fissure opened in the upper part of the southern face of the cone, from which lava flowed towards the Camaldoli. Other minor streams of lava flowed, and, indeed, so abundant and diffused was the emission from the cone, that Prof. Palmieri writes: "It (the cone) seemed completely perforated, and the lava oozed, as it were, through its whole surface. I cannot better express this phenomenon than by saying that Vesuvius *sweated fire*."

During this profuse outpouring of lava there were terrific discharges from the summit, accompanied by loud bellowings and thunderings. The smoke and ashes are estimated to have reached a height of between four and five thousand feet above the summit of the mountain. From a remarkable photograph of the eruption at its maximum, taken from near Naples,† the regularity of the usual pine-

* "The Eruption of Vesuvius in 1872," by Prof. Palmieri. Translated by Robert Mallet.

† Photography was first used for d icting eruptive phenomena on this occasion.

tree form of the smoke appears to have been considerably interfered with by the wind, which inclined the whole towards the south-east.

A rain of white ashes, lapilli, small fragments of scoriæ, and dark sand descended, and darkened the air, especially on the 28th, when the inhabitants of the neighbouring towns were terror-stricken, the thundering noises all the time continuing, for the explosion appeared to gain strength after the cessation of the great lava-flow of the 27th. The whole history of the volcano shows that darkness, caused by the ejection of ashes, and loud thunderings inspire more terror in the minds of the inhabitants of the surrounding towns than do lava-flows, although, with the exception of that of 79, the eruptions have caused little devastation in towns and villages, except by lavas. Considerable injury to crops has, however, been sustained, both from dry ashes and from ash-mud. The people of Naples went about the city with umbrellas and covers for their faces, to protect themselves from the falling ashes, which were abundant even there, and the lighter portions were carried by the wind to great distances.

A remarkable feature of this eruption, and the first of the kind Prof. Palmieri thinks authenticated, was the "external eruptions" that occurred on the great stream of lava that flowed by the Observatory. So decided and conspicuous were these explosions and ejections of projectiles that one is distinctly

recognisable in the photograph before mentioned. These the Professor considers to be essentially different from the apparently somewhat similar miniature eruptions of 1850, 1855, and 1858, which he believes to have emanated from fissures below the lava. The three eruptive points of 1872 were each in action from fifteen to twenty minutes, and then entirely disappeared, being carried away by the fiery torrent. Mr. Mallet seems to justly say that they were "most probably merely the bursting upwards of large bubbles; that is, of cavities formed in the mass of the more or less liquid lava by intestine movements, as its mass winds and rolls along, and by the aggregation of smaller cavities—all being filled with steam and gases." Nevertheless, it seems to me that Palmieri thinks rightly that they "cause the recognition of a power in the lava itself to form eruptive fumaroles," and if so, they must have an important bearing on the causes of, if I may so term them in contradistinction, the internal eruptions, or the principal eruptive phenomena.

The lava that was poured out so abundantly on the 26th and 27th, besides being so sadly fatal to life as in the occurrence before stated, was most destructive to property. On the south side of the mountain the lava did not travel further than the borders of the cultivated region, and so the beautiful slope towards the sea and the towns at its foot were uninjured, and similarly the eastern slope with Bosco-tre-Case and

Bosco-Reale escaped. On the western side, however, an immense flow, proceeding from the great fissure, descended the Fosso della Vetrana and so through the Fosso di Faraone to the Plain of the Novelle, and these devastating fields, gardens, and houses, caused great havoc. One still more destructive stream flowing over that of the eruption of 1855, which partly destroyed Massa di Somma and San Sebastiano, again swept over parts of these villages, obliterating in the case of Massa one-third, and in that of San Sebastiano nearly a fourth of the houses. So rapidly did the flood of lava come upon the villagers that they were barely able to save some of their portable property, and many lost everything. Prof. Palmieri thinks that if the emission had not greatly diminished, as it did after a brief outflow, the lava in twenty-four hours would have passed through Ponticelli and reached Naples itself. It was estimated that the amount of lava emitted during this eruption was about 600 millions of cubic feet, and that the value of the property destroyed was over three million of francs.

On the 29th of April the explosions were less violent, and at night became less continuous with decreased noise, while on the following day all the eruptive symptoms were quite subdued, and on the 1st of May the eruption was at an end. Its decadence was, however, accompanied by a storm with thunder and some rain. "The grass, the seeds, the vine tendrils, the leaves and tops of the

trees dried up immediately, and the country was changed from spring to winter." The cause of this notable injury to vegetation was doubtless the conveyance by the rain of destructive gases and sea-salt, obtained from the canopy of smoke and ashes above, to the more tender parts of the plants. A few years ago a south-west gale, by carrying sea-spray inland, produced a somewhat similarly injurious effect on the early foliage of the oaks of Sussex which had just put forth their leaves.

The chief characteristics of this eruption were its long-continued simmering and its most violent but brief ebullition at the close, the "exterior eruptions," and the great amount of volcanic lightning with thunder proceeding from the canopy of smoke above the mountain.

The curious phenomenon of a great accumulation of insects (*Coleoptera*) on the cone was observed after this as after previous eruptions. Mr. Mallet states that he has observed a similar abundance of insect life, great and small, on Etna, and suggests that it may arise merely from the local dryness and warmth, and the *nidus* afforded by the vesicular lava for the eggs and earlier stages of insect life.

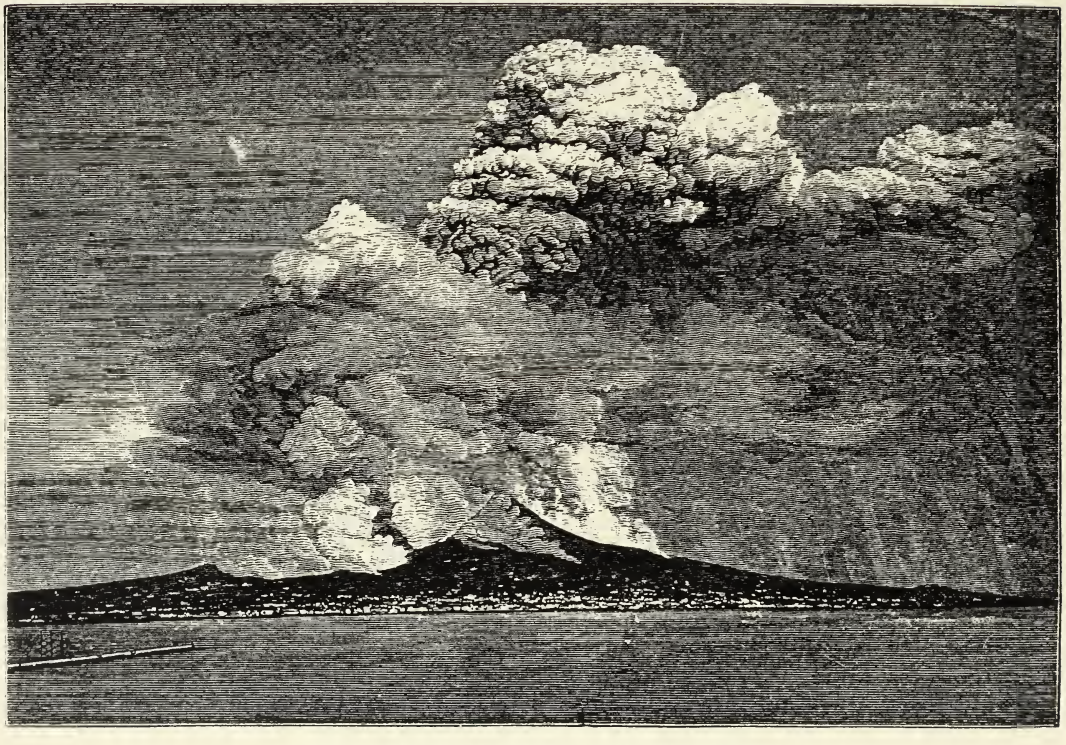
As was to be expected, the violent eruption of 1872 had the usual effect produced by paroxysmal eruptions of reducing the height of the mountain a little, and forming a large crater. The crater now produced was divided by a "Cyclopean wall," and

Prof. Palmieri found its depth to be more than 800 feet, with a tunnel near the bottom of the eastern half perforating the side.

That abundant product of Vesuvius, common salt, or "sea-salt," as Palmieri prefers to call it, from its containing, besides chloride of sodium, the other compounds characteristic of the salt of the sea, so extensively and conspicuously covered the ground that "not only the Vesuvian cone, but the whole adjacent country appeared white for many days, as if covered with snow, when exposed to sunlight."

1873.—The very violent and destructive eruption of 1872 was, as was to be expected, followed by a period of tranquil inactivity, and nothing noteworthy has been recorded of Mount Vesuvius during the year 1873. Visitors to the now quiet volcano were numerous, and the rugged and still hot lava was traversed by travellers from all countries, while the ruins at San Sebastiano and Massa di Somma attracted great attention, affording, as they did, most cogent evidence of the destructive power of the now slumbering giant of the Neapolitan Campania.

1874.—The repose of 1874 was not quite so complete as that of the preceding year. On the 3rd and 4th of January a rumbling noise was to be heard at the crater, while dense smoke gave evidence of incandescent matter being not far distant. Subsequently the restlessness of the volcano some-



VIEW OF THE GREAT ERUPTION OF 1872.

(From the first Instantaneous Photograph ever taken of an Eruption.) *(Judd's Volcanoes.)*

what increased, and showed itself particularly towards the north-east of the crater, and globes of smoke were evolved, with a hissing sound and odour of hydrochloric and sulphurous acids. Near the end of the great fissure of the eruption of the previous year, sublimations of alkaline compounds were deposited on the surface. On the 21st of January a slight shock of earthquake was felt at Casamicciola, on the island of Ischia. The volcano, however, was not further active, with the exception of a slight eruption on July 18th, giving off clouds of smoke only, during the year, and at its termination was quite quiescent.

1875.—Neither explosive ejections of fragmentary matter nor emissions of lava appear to have been observed during the year 1875, but there was a considerable evolution of gases, and it is stated by Mr. Rodwell that carbonic acid diminished and hydrochloric acid commenced, thus indicating the highest stage of fumarole activity. During January much sulphurous acid was given off, rendering a descent into the crater impossible. In December, however, there were indications of renewed activity. Earthquake shocks were felt at Naples, and a large portion of the interior of the great crater of 1872, towards the north-east, fell in, and dense clouds of black smoke arose, and on the 19th, lava was seen below, which became more conspicuous on the 20th, but no eruption took place during the remainder of the year.

1876.—In March, 1876, great volumes of smoke arose from the crater with, at night, the reflection of glowing lava below, and the instruments at the Observatory were in a condition of disturbance. The lava gradually increased in height, and ultimately rose to the top of the chasm produced by the giving way of the floor of the crater in the previous December, while slight ejections formed a small new cone.

1877.—At the beginning of January in this year, Palmieri reported that the Observatory instruments were agitated, and that smoke was issuing with greater force from the crater, and with increased volume. The lava of the volcanic axis gradually increased in height, and ultimately rose to the top of the chasm in the crater floor, and slight ejections of fragmentary materials gave a small new cone to the interior of the great crater.

In the year 1878, Vesuvius had a very considerable access of activity, attaining a stage which might be termed completely "Strombolean." The coming eruption was presaged in April by a column of what is called "flame" arising at short intervals from the summit of the mountain. This would doubtless be the reflection of the lava in the crater rendered intermittent by the occasional intensity of the blackness of the smoke consequent upon temporary increase of the volcanic ash ; but it was not until the following September that decided eruptive symptoms were manifested. In this

month it is stated that volumes of lava were projected 100 yards above the new crater, accompanied by loud explosions, and that no "flames" were visible. This statement is difficult to understand, for if an accurate one, it was a most unusual phenomenon, and of great importance in vulcanology. After this there was a slight diminution of activity, which Palmieri notes was increased at the time of new moon.

At the beginning of October, the crater appears to have been, by the continuous uprise of the lava, almost full of the fiery fluid, and on the 1st of November it flowed over the lowest part of the rim, or rather it carried away the loose fragmentary crest of a depression in the rim, and so formed a lip over which it continuously flowed. This was on the north-west side, giving to the lava a direction that took it into the Atrio del Cavallo, and thence through the same ravine and over a similar course for some distance, as the lava of 1872. The main flow divided into three streams, neither of which reached the cultivated region, and so no devastation was caused by this eruption. The flow of lava was not of long continuance, but on the 29th of December, Mr. Rodwell says that the new cone was pouring out vast volumes of steam and smoke, accompanied by detonations and loud noises as if lava was surging in the crater, the walls of which were 100 feet high. The sublimates then observed were chiefly sesquichloride of iron and sea-salt, but

Palmieri detected some sulphates, boracic-acid and lithium. This new lava was very leucitic, though not resembling that of the eruption of 1872, and when viscous could easily be drawn out into fine threads, but when cold it was quite black and had a good lustre.

1879.—As in the preceding year, there was no marked activity of the volcano until November, when Vesuvius, it was said, had on the 3rd of that month again "hoisted its red flag," that is the crateral lava manifested itself by illuminating the ascending volumes of steam, thus producing the flame-like light that is so ominous when seen from Naples. At this time the cone that had been gradually growing in the centre of the great crater of 1872 was a few yards above the enclosing rim, like, as was said, a small cup in the middle of an immense saucer, which latter was almost full of lava that had been flowing over a depression since October the 30th.

Continuous, though slight, activity prevailed for several weeks, when, on the 17th of December, the maximum activity was recorded, and the snow-capped mountain was seamed with fire on the side above Portici, when it presented a striking and beautiful spectacle. On the next day the reduced disturbance was accompanied by local shocks and heavy breathing, but there was no pronounced explosion. At the end of the year there was much smoke, but no lava flowing, while the new cone was

50 feet above the great crater-rim. Prof. Palmieri observed that the volcanic energy was greatest at times of new and full moon.

In this year, Prof. Scacchi, the eminent Professor of Mineralogy in the University of Naples, reported the discovery of a new chemical element in some yellow and green incrustations on the lava of 1631, which he called *Vesbium*, from an old name of Vesuvius mentioned by Galen. These substances were accordingly named the "Vesbiate of Aluminium" (the yellow) and the "Vesbiate of Copper" (the green). (See Vesbine, Chapter X.)

1880.—In January of 1880 there was increased energy, and the eruptive cone gave off volumes of dense white steam, while large masses of scoriæ were at the same time ejected to a considerable height at frequent intervals, while lava rose in the volcanic tube, very frequently flowing from the vent through a hole in the side of the small cone near its base, of about five feet diameter. One stream descending on the north-west side of the cone reached the Atrio del Cavallo.

In the lateral "bocca" the lava was much agitated, and Mr. Rodwell says it was thrown up three or four feet above the opening, in every respect resembling small geysers he had seen in Iceland. Another but smaller stream of lava also flowed from the summit into the Atrio, but on the next day the activity diminished. The lava of this eruption was very leucitic and similar to that of 1871, and

the fumaroles yielded copious sublimates of chlorides and sulphates, while the spectroscope revealed the presence of the metals lithium and thallium. Hydrochloric and sulphurous acid gases were given off.

At the time of full moon in the latter part of March, greatly increased volcanic activity was manifested. Two new mouths opened at the foot of the new cone, from which jets and red-hot stones were ejected to a great height, while lava was emitted from the central crater. After a time of suspension of activity, volcanic energy again manifested itself in the autumn, and at the beginning of November lava was flowing freely. The eruption continued to increase, and the lava streams multiplied, presenting, towards the end of the month, a magnificent spectacle. An outwork built to protect the upper station of the Funicular Railway, which had been opened in the previous June, was destroyed by the lava-flow, but the railway itself remained uninjured.

1881.—At the beginning of March, 1881, lava again flowed copiously, and seamed the snow-covered mountain with fire. This flow was on the north side, and the lava, being both very mobile and abundant, the course threatened to extend further than the Atrio del Cavallo, into which the lava first flowed. Another stream descended the side of the cone a little further to the west before the end of the month.

The large crater left by the eruption of 1872 had been filled for a long time with lava to the level of

the lowest depression in its rim, and the plain of lava so produced formed a platform, on which arose a small, steep-sided, eruptive cone. This was partly destroyed in July of this year by an access of eruptive energy, which left an increased opening with lower enclosing walls.

In a tunnel of lava-exit through the walls of the eruptive crater, Dr. Johnston Lavis obtained thirty stalactites, which were chiefly composed of common salt or halite, and were highly diliquescent. Together with chloride of sodium, there were present chlorides of potassium, iron, and manganese, with sulphates of soda, potash, iron, and copper. There were also crystals of halite, sylvine, and a few of molysite. These stalactites had been formed by rain-water percolating through decomposing lavas, and re-depositing in the interior of the tunnel the extracted soluble compounds. The month of December of this year again witnessed an emission of lava, this time on the eastern or Pompeiian side of the great cone. Towards the end of the month the eruption increased, and on Christmas Day a fissure opened on the north side and extended a third of the way down the great cone, with a breadth at the top of 120 feet. The copious flow of lava descended into the Atrio del Cavallo too far to the north to do any damage. On this occasion also a covering was formed over the descending flow of lava by surface solidification, and a tunnel or tube was so produced. The lava is described as having had almost

the liquidity of water, and some experiments by Dr. Lavis led him to conclude that, contrary to Prof. Palmieri's previously obtained results, cold solid lava has a higher specific gravity than the incandescent fluid.

On the lowering of the level of the lava in the volcanic tube, a remarkable alteration took place in the character of the ejectamenta. Instead of soft masses of pasty lava, there were discharged rounded fragments of solid and evidently old lava, together with volcanic ashes. As suggested by Dr. Lavis, this may be explained by regarding the fragments of solid lava as derived from the walls of the volcanic tube, which were no longer supported by a column of lava, and which therefore bit by bit fell into the line of fire of the volcano and were consequently discharged, the ashes being formed by the attrition and trituration of these fragments.*

1882.—This year opened quietly, and it was not till the middle of January that any light on the summit was seen at Naples, and this ceased before the end of the month, but revived in February. In March and April there was no activity visible at a distance. Towards the end of April there was a crater less than 400 feet diameter, occupying about one-third of the area of the great crater of 1872, but not concentric with it. There was still a small flow of lava, reaching to the Val del Inferno.

* For a detailed account of Vesuvian activity in 1881, see Dr. Johnston Lavis in *Nature*, vol. xxv., p. 295.

A slight increase of activity coincided with an eclipse of the sun in the middle of May. This was followed by greater tranquillity till the first week in June, when, at the time of earthquake shocks in Isermia and Vinchieta, in the Apennines, there were increased explosions, but these soon ceased, and till the end of the month there was no reflection seen. At the beginning of July, however, the activity increased, and lava flowed again freely.

From this time till the end of the year there was little activity, although smoke was constant, and a slight flow of lava continued in the direction of Pompeii, but stopping at the edge of the Atrio. Dr. Lavis, on visiting the summit in July, found a fourth crater forming. The old floor of the 1872 crater was much decomposed, and covered with fumaroles towards the south-west.

1883.—Throughout the whole of the year 1883, Vesuvius was in a condition, to use a somewhat paradoxical phrase, of much-disturbed tranquillity, during which, in every month, the volcano manifested sometimes considerable activity, and oftentimes almost complete quiescence, though absolute dormancy was never attained. A gentle and quiet emission of a small volume of lava continued for lengthened periods, and occasionally increased to a considerable flow, while the ejectamenta only seldom reached any great altitude.

In the latter part of February there was a stream of lava descending towards Torre del Annunziata,

but it did not continue to flow more than a day; and in the first half of March there was a somewhat copious emission of lava, but, with the exception of an increase on the last day of the month and during the third week in April, there was not much action till the 18th of May, when the projectiles were both high and brilliant, and on the 25th of the same month there was a considerable explosion.

In this state of feebleness, with occasional displays of increased power, Vesuvius continued through the months of June and July, and at the end of the latter month, when the disastrous earthquake at Cassamicciola, in the neighbouring island of Ischia, occurred, the volcano was almost in its quietest phase. It was not until after the middle of August that there was again an abundant flow of lava, and this diminished two days afterwards. Again there was little action till the 7th of October, when, and once or twice in this month afterwards, there was vigour displayed. In the middle of November the volcanic energy, for about four days, was high, and then there was a subsidence that, broken only by a spurt on the 27th of December, continued till the end of the year.

On visiting the crater on the 22nd of April, Dr. Lavis found much fine fillamentose lava spreading over, as a light cover, the crater floor, and, from the rapid decomposition of old lava by acid vapours, crystals of pyroxene and of leucite were very abundant. It may be worthy of note that on

the 16th of February of this year an earthquake shook the city of Bologna and the whole of southern Romagna, and at the same time there was an increase in the activity of Vesuvius.

1884.—A somewhat greater activity appears to have prevailed during the year 1884, though only once or twice did it rise to the dignity of an "eruption." Strombolean activity may, perhaps, best describe the almost constant ejections of fragmentary material going on throughout the year.

On the night of the 9th of January there was a conspicuous display of lava and projectiles, that was called in the English newspapers "a violent eruption," with a flow of lava into the Atrio del Cavallo at the Pompeiian end, but it quickly terminated, and on the 12th there was a great diminution of activity. Much filamentous lava was again produced.

The following useful scale of Vesuvian activity is given by Dr. Lavis, in his Report to the British Association in 1885, and also in "Lo Spettatore del Vesuvio dei Campei Flegrei," by means of which the eruptive phenomena may be briefly and comprehensively recorded by an observer at Naples after nightfall whenever the mountain is free from cloud:—

SCALE OF VESUVIAN ACTIVITY.

1st degree.—A faint glimmer, above the main vent, interrupted by complete darkness.

2nd degree.—The glimmer is continuous, but the ejection reaches hardly above the central crater-rim at most.

3rd degree.—Glimmer continuous and well marked; the ejections are

distinctly discernible as they rise and then fall on the slopes of the cone of eruption and roll down its slopes.

4th degree.—The ejections reach a considerable height, are brilliant, and light up the top of the great cone.

5th degree.—Verging on an actual paroxysmal eruption, the ejections are shot up very high, being only very slightly or not at all influenced in their course by a strong wind. Each explosion follows with much rapidity, and corresponds with the "boati" heard all around the west, south, and south-east slopes of the mountain.

From the record given in "Lo Spettatore" of the results of the application of this scale in the year 1884, it appears that in 239 observations the activity was at $4\frac{1}{2}°$ three times, 4° five times, 3° twenty-six times, $2\frac{1}{2}°$ seven times, 2° fifty-four times, $1\frac{1}{2}°$ thirty-two times, and at the lowest stage, or 1°, one hundred and twelve times.

The fluctuating character of the volcanic energy of Vesuvius during a period of Strombolean activity is well shown by the register for a single month, which may be thus tabulated :—

FEBRUARY, 1884.

1st, cloud	8th, 3°	15th, 1°	22nd, $1\frac{1}{2}°$
2nd, cloud	9th, $2\frac{1}{2}°$	16th, 1°	23rd, 1°
3rd, $4\frac{1}{2}°$	10th, 1°	17th, 1°	24th, 1°
4th, 3°	11th, 1°	18th, 1°	25th, 1°
5th, 4°	12th, 1°	19th, $2\frac{1}{2}°$	26th, 1°
6th, 4°	13th, 1°	20th, 2°	27th, 1°
7th, 3°	14th, 1°	21st, 2°	28th, 1°

The small flow of lava which had been going on continuously, with an occasional increase, since December, 1881, was considerably lessened in March of this year; and during April, May, and

June the activity was very languid. A slight but short increase in July was followed by a diminution that continued till the October following, when 3° of activity were registered on several occasions. Until the end of the year the volcano continued in the same state of varied but low activity.

Changes of more or less importance modified the interior of the old great crater of 1872, new cones, new mouths, new fissures, being formed and obliterated by the alternation of the eruptive phases. A modification of the outline or profile of the great cone was also produced by the long-continued ejection and emission of materials, and its greater accumulation on one side, which gave a double hump on the profile of the slope, as seen from Torre del Greco and the Camaldoli della Torre.

1885.—Strombolean activity still characterised the state of Vesuvius throughout the year 1885, with the usual alternating increase and decrease. In the middle of January the eruptive energy rose to 4° for two days, but speedily fell again to 1°. A new mouth was formed on the 18th of January, on the eastern side of the eruptive cone, where was the cleft of 1882, and the lava descended through the conduit then formed. In the latter part of the month, Dr. Lavis found near the eruptive mouth mammilary, submetallic-looking, dull-brown masses, which, when struck with a hammer, proved to be as soft as starch.

There was a somewhat abundant flow of lava

early in May from a rent not far distant from the upper station of the Funicular Railway, which flowed in the direction of Pompeii and Torre del Greco, but did not extend very far. The rent on the cone was the termination of an interior fissure which had been gradually forming, proceeding radially outwards, and the partial in-filling of which with lava formed a new dyke. A slip of part of the cone gave a section of this, showing it to be hollow. The lava flowed in two parallel streams about 150 feet apart, and moved at the rate of about three feet per second, thus giving about 10,000 cubic yards of lava rock in twenty-four hours to the mountain slopes. Lava appears to have flowed continuously, though in diminished quantity, until the end of the year.

1886.—A cessation of the lava-flow from the rent of the previous May, with the exception of a slight emission for three days early in January, continued until February 4th of this year, when an abundant stream issued to the north of the principal vent of the volcano, and flowed down the northern side of the cone. The lava, moving at the rate of about three feet in five seconds, gave a mass of material of nearly 30,000 cubic yards. After the 11th of February the outflow diminished, and ceased in the third week in March; but there were slight flows in April, and unimportant variations in May, during which month there was an eruption of Mount Etna, but with which Vesuvius did not show any sympathy.

In June the eruptive cone was found to be greatly increased in height and in the diameter of its base, since it covered nearly all the crater rings on the floor of the great crater of 1872. On the 28th of this month this cone partly gave way, and the upper part crumbled in, and at the same time there was an increased flow of lava. Then followed a cessation until the 8th of July, when the fused rock flowed into the Val del Inferno, and, then descending, reached the cultivated region, destroying some of the trees of the woods belonging to the Prince of Ottajano and injuring some vineyards. Again, on the 21st of the same month, the lava caused a similar extent of injury, and a considerable flow took place in the first week in August, when it was found that the eruptive cone had been reduced by about 100 feet. So much chloride of copper was sublimed that Dr. Lavis speaks of the nails in his boots being plated with the metal. In the next month (September) the lava once more reached the cultivated lands at the south end of the ridge of Somma, but little damage was done.

Variations of lava-flow continued until the end of the year with ejections of ashes that again increased the eruptive cone. The eruptive crater became oval with the larger end towards the east, and early in November a new rent appeared on the eastern slope of the great cone, and near to the opening of 1881-2, while there was found a new fissure in the

floor of the great crater of 1872 and having a north-east direction.

1887.—Few changes and little activity characterised the state of the volcano throughout this year, the eruptive energy not exceeding the third degree. A small flow continued to descend the great cone on its eastern side, under the cover of a lava-formed tunnel, and to emerge in small streams at its base in the Val del Inferno, not far from the Pedamentina.

1888.—During the greater part of last year the activity of the volcano was similar to that of 1887, but the summit of the new eruptive cone had attained in June the level of the crater's rim, and a small emission of lava continued. The close of the year was marked, however, by an increase of activity, as the following paragraph from *Nature* of the 28th December, giving the latest information of Vesuvius in 1888, records: "Vesuvius has lately been very active. It has been rapidly throwing up a new cone of eruption about thirty to forty yards to the south-west of the original one, and the fissure across the crater plane towards the west-south-west is increasing in size, and is richer in acid and incrustations. It is possible, therefore, that an eruption may take place soon on that side of the cone, since the vent tends to shift along the fissure pointing in that direction."

Thus it will be seen that Vesuvius has been in a state of slight activity for six years. Such a long-

continued, slightly eruptive condition of the volcano may have occurred during previous centuries, as its minor and less striking phases were not recorded. Indeed, the present assiduous and unremitting observation of the condition of Vesuvius is altogether without parallel, and the warmest thanks of all vulcanologists and students of science, as well as of all lovers of Nature, are due to Prof. Palmieri and Dr. Johnston Lavis, as well as to the British Association for its annual grant in aid of this important and most interesting work.

CHAPTER VII.

GEOLOGY OF VESUVIUS.

Vesuvius Geologically Instructive and Illustrative—Three Geological Divisions—The Cone : Cause of its Regularity; its Structure, Lavas, Minerals—Monte Somma : Change of Position of Axis, Formation of Great Crater-Rings, Structure, Dykes, Minerals—The Base : Concavity of Volcanic Outlines, Structure Concealed, Hypothetical Origin, Geological Age—Theory of Craters of Elevation.

The geology of Vesuvius is as interesting as its history; indeed, the one is a sequel to the other, for the geology of the volcano is the result of its remarkable history, and a knowledge of the latter is a necessary preparation for the consideration of the former, since an acquaintance with the character and effects of the various eruptions which have modified the form of the mountain and gradually brought it to its present state forms a basis for a correct understanding of its structure and geological formation.

Mount Vesuvius is an especially instructive volcano to geological students, who find in this easily accessible mountain of moderate elevation illustrations of almost every form of volcanic phenomena, and in its frequent eruptions almost every phase of volcanic activity.

But although the mountain is a complex one, and largely illustrative of varied volcanic phenomena, it is not difficult to obtain a clear perception of its

structure and the formation of each portion that contributes to its peculiar configuration. The whole is readily divisible into three parts, that, although united and forming one mountain mass, are in many respects distinct, as well as the production of the volcanic activity of three different epochs. These three chief geological divisions of the volcano are :—

1. The Cone;
2. Monte Somma; and
3. The Base, or body of the mountain, underlying both Somma and the Cone.

The Cone.—The newest of these three portions of the mountain, the cone, which we have seen gradually growing up from the accumulation of the ejectamenta of successive eruptions, demands attention first, since it will explain not only the structure of the other two portions, but the structure of volcanic cones generally, of which this is a typical example. In addition to the light thrown upon its formation by the accounts of past eruptions, there have been special and remarkable opportunities for actually observing its internal structure and anatomy, so that no doubt remains either as to its structure or the manner in which it has been built up.

The Cone is simply the resulting accumulation of successive falls of ashes, lapilli, cinders, and scoriæ ejected, and of solidified lava-flows emitted, during many eruptions, and is, therefore, composed of a

series of beds or sheets formed of these materials, and lying more or less parallel with the exterior slope. They consequently have a quaquaversal dip, or an inclination outwards on all sides from a central axis, which is the tube, funnel, or chimney of the volcano, and through which the lava rises from the deep-seated source of the volcanic energy in the interior of the earth.

Did a volcano eject only loose solid material, there would be no difficulty presented by the conical form of these mountains, for, notwithstanding the influence of the wind in determining the side on which the greater amount of the ejected fragmentary material would fall, yet the various directions of the wind during different eruptions would account for the ultimate regularity of the conical outline. Some crateral cones consist only of loose material—notably those in the Phlegræan Fields — but the great majority of volcanoes emit lava which forms beds of solid rock of various widths, and the result of the whole action is still a cone. The flows of lava must therefore be as diverse in their direction as are the falls of ejectamenta in the direction of their maxima. The many different points from which the wind blows at once account for the latter, but what can ensure such a continuance of diversity of the points of emission as will account for the former? To reply to this, it may be assumed that a soiidified lava-flow will strengthen the adjacent

parts of the side of the cone, and that consequently another part of the circumference of the crater-wall will yield more easily to the pressure of the fluid mass the next time the crater fills, or partly fills, with lava, and so the succeeding flow will be over a depression in the rim or from an aperture through the wall at another part of the circumference of the cone. Thus the flows will in succession commence their descent of the exterior of the cone from different points of the circumference of the summit ridge, or from openings or tunnels at different azimuths or meridianal positions on the slope of the cone.

The ultimate and general result of a large number of eruptions must consequently be that in the aggregate there will be an approximately equal amount of compact rock, as well as of loose material, on every side of the central axis or volcanic tube, and that although each bed of compact solidified lava may be but narrow, yet a section of the interior will display on any side a roughly regular alternation of beds of compact rock and beds of loose material.

The great enlargement of the crater of Vesuvius in 1822, consequent upon the violent paroxysmal eruption of that year, showed very distinctly the structure of the cone, clearly establishing the fact that it was built up as just stated. This was most important evidence, since the crater was so large and deep, that the very heart of the cone was exposed, and so the structure of the whole was

revealed. And this regularity of alternation is moreover continued into the newest portions, for Prof. Palmieri, after the eruption of 1872, found in the interior of the crater of that year exactly the same structure—compact beds of lava rock alternating with beds of loose material, scoriæ and ashes.

A crateral section necessarily shows horizontal edges of the lava beds, but their dip, or angle of inclination downwards, was ascertained in 1822, and it was then found that the beds declined outwards at angles varying from 26° to 30°. This is not quite so great an inclination as that at the upper part of the exterior surface, but this greater inclination of the outside slope may be accounted for by the greater amount of scoriæ and ashes which falls near the summit, and which lies and accumulates at a high angle of slope that, together with the more frequent dyke-forming injection of lava into fissures in the part of the cone nearest the central lava conduit, increases the angle of slope of the next formed solidified lava-flow, and consequently the upper beds of lava in an ordinary volcanic cone have a greater inclination than the lower ones.

That compact lava-rock can be produced on steep slopes by the solidification on them of lava-flows has been shown by Sir Charles Lyell in his paper to the Royal Society, "On the Structure of Lavas which have Consolidated on Steep Slopes," in which

he gave the results of personal observations on the subject at Etna. Both Dufresnoy and Elie de Beaumont had previously asserted that only thin scoriaceous beds could be produced on steep slopes, and that compact and crystalline lavas must have consolidated on slopes not exceeding 3°. At Aci Reale on the coast, at the foot of Etna, Lyell found compact lava-rock 20 feet thick that had consolidated in 1669 at an angle of 29° over ground previously highly cultivated. In the Cava Grande on the eastern flank of the volcano there was found still more cogent evidence, since here is a very compact bed of rock five feet thick lying at so high an angle as 35°, the solidified lava of a branch of the great flow of 1689, and reposing on a slope of the side of a ravine in which there has been no change of level or slope since that time. And still more remarkable than this, Sir Charles Lyell found stony lava of the eruption of 1852 covering a precipice, the Salto della Giumenta, at angles of 35°, 40°, and even as high as 45°, and indeed at one spot he says at 49° if not 50°. At the Cava Secca, at Giuamicola, and at the Casa del Vescovo, highly inclined beds of compact stony lava also testify abundantly to the formation of such beds by the solidification of fluid lava on steep slopes.

But in addition to the parallel beds of scoriæ and lava, there was found to be walls of compact rock cutting through them at high angles up to the vertical, and that this rock was solidified lava too.

These "dykes," as they are termed, are the result of the infilling of radial fissures by molten lava from the volcanic tube, and they therefore proceed from the central axis towards the exterior of the cone. Sometimes the fissure has been a way of exit for the lava, which on the cessation of the interior dynamic propelling force has solidified, and so filled up, or partly filled up, the conduit with compact rock. The general effect of these dykes of tough basaltic rock is to greatly strengthen the cone, and bind together the whole structure of beds of incoherent scoriæ and ashes, and narrow beds of lava-rock, and so to enable it to more effectually withstand subsequent rending and tearing eruptive forces.

A diagrammatic section of the cone would give an appearance of regularity and continuity that is deceptive and yet is justified. For although the beds of lava do not extend round the cone, and are indeed for the most part of little width, they thin out towards their sides, and others, likewise thinning out, and being partly on the same level, a section across would show on each side of the axis corresponding or similar beds, and so give an appearance that would *primâ faciæ* lead to the conclusion that the lava extended in sheets or complete coats one over the other, with intermediate coatings of loose materials, quite round the cone.

The mouth of the central volcanic tube and axis of the cone, the Crater, varies in size and shape with almost every eruption as already explained. (See

Chapter III.) Sometimes it is a vast more or less circular hollow with an irregular rim of half a mile or more in diameter, and sometimes it is a very small opening of not more than a hundred yards wide. Sometimes, too, as after the eruption of 1822 it is a profound abyss of a thousand feet in depth, and at other times it is a shallow saucer-like amphitheatre, with an almost level lava-formed floor, having in one or more places a small mouth or fumarole whence issue fumes and steam.

As shown by the previously narrated history of the volcano, the whole of the present eruptive cone of Vesuvius has been produced since A.D. 79, for the eruption of that year not only destroyed the south-western side of the great crater of the prehistoric volcano, but left, there is every reason to believe, a cavity so deep as to reach below the level of the sea. Such a cavity would be funnel-shaped, or a hollow inverted cone, and the infilling of its apex would necessarily be the commencement of the formation of the present eruptive cone, which has by successive eruptions attained its present proportions, with, however, occasional checks to its growth by the destructive action of such terrific outbursts as those of 1631, 1794, and 1822, when for a time the summit was considerably lowered, and the cone was proportionally more truncated.

The lavas of the cone, those emitted in modern times, appear for the most part to be markedly different from those of earlier epochs, for they

contain usually little free leucite, which so conspicuously distinguishes the ancient lavas of Monte Somma. There has, however, been a noticeable increase in recent eruptions of the amount of free leucite, and the lava of 1871 was especially leucitic. Pyroxene and olivine take the place of the leucite and constitute many of the modern lavas true basalts or dolerites, the composition being pyroxine or augite, a triclinic felspar, with olivine and ferruginous matter, blended together in a compact and homogeneous mass, and forming a hard dark-coloured rock when cooled in mass, but when solidified from small streams that have cooled rapidly and without pressure, the lava is very scoriaceous and vesicular or spongiform in texture, and has a harsh and trachytic feel.

Prof. Palmieri, describing the manner of solidification of lava-flows, writes as follows :—

"The part which begins to harden breaks readily in some lavas into fragments which float on the viscous fluid beneath ; these, increasing in number, with distance from the source, conceal the molten matter beneath and retard its progress, and at last nothing is seen but the more or less red-hot scoriæ moving along. These lavas I shall call 'Lavas with fragmentary scoriæ.' On other occasions a skin forms on the surface of the lava, which, gradually thickening, keeps flexible for some time, and then wrinkles or swells or extends and breaks to give egress to the hot fluid within, which, in its turn, skins over and repeats the same phenomena. This

I shall call 'Lavas with a united surface.'" Palmieri states that the former of these two classes comprises the lavas with little leucite and abounding in pyroxene and olivine, while the latter includes those rich in leucite and containing little or no pyroxene.*

It is, too, a remarkable fact that, although more species of minerals have been obtained from this mountain than from any other equal area in the world, yet the modern ejectamenta forming the present cone of Vesuvius have yielded but a small number. Yet again the more recent eruptions have produced an increased number. Augite or pyroxene, titaniferous iron, hornblende, sodalite, mica, breislakite, leucite and tenorite are sometimes found in the modern lavas in distinct crystals. Cotunnite, a chloride of lead, was found after the eruption of 1822 inside the crater, and was a marked constituent of the lava of 1855, which was unusually fluid, rendered so, it has been thought, by the presence of this mineral. Prof. Palmieri says: "I found the crystallised chloride of lead, or 'cotunnite,' as it is called, for the first time in the lavas of 1855, and thought it a singular circumstance; but from that time I recognised it in all the lavas, though not always so beautiful and abundant; and even when not found as a distinct substance,

* "Eruption of Vesuvius in 1872," by Prof. Palmieri, translated by Robert Mallet, page 103.

I observed it in combination with chloride of copper." * (See Chapter X.)

Monte Somma.—This (sometimes named Monte di Somma, from the town of Somma, in the plain below) is the second of the three great divisions of the mountain, and is the remaining portion of the enclosing wall of the vast ancient crater which existed before the Christian Era, and which was not active during the whole of the preceding historic period. The western and southern sides of the crater wall having been destroyed, the remaining half, Monte Somma, forms a semi-circle, with its concave or inner side facing the Cone on the north and east.

It has been calculated that the centre of the base of the modern cone is coincident with the centre of the circle, of which the escarpment of Somma forms a part. Thus it is seen that the vent, or eruptive axis, of the modern Vesuvius was also that of the last stage of the pre-historic volcano, and that consequently there has been no change in the position of the axis as a consequence of its long dormancy, that, in fact, the axis of the modern Vesuvius coincides with the position of the axis of the great crater of which the Atrio del Cavallo formed a part.

It has been found, however, from careful calculations, that the curve of the Atrio is not concentric

* Palmieri, "Eruption of Vesuvius in 1872," page 110.

with what remains of the circumference of the original simple but lofty conical mountain, the outer or convex side of Monte Somma, and that consequently the centre of the inner curve is not the centre of the outer one. But as the centre of the outer curve must have been the primary eruptive axis, and the centre of the inner one is the present eruptive axis, it follows that the position of the axis must have at some period been changed. This alteration of the position of the eruptive axis has been calculated to be no less than about a thousand yards towards the south or a little to the west of south. A change in the position of the axis of a volcano is nowhere perhaps more conspicuously seen or more beautifully shown than in the Puys Noir, Solas, and La Vache, in Central France, and in the island of Vulcano, one of the Lipari Islands, where, in both localities, there are three contiguous excentric craters, clearly indicating that the eruptive axis has twice changed its position. At Mount Etna, too, the Val del Bove, on its side, is doubtless the old crateral opening of the early axis of the volcano, while the present eruptive vent at the summit of the mountain, Mongibello, is four miles distant.

It is doubtless in consequence of a change in the position of the axis during the middle period of the existence of the Vesuvian volcano, and the consequent oblique or irregular truncation of the cone at that time, that is due to some extent the absence

of an opposing ridge on the southern side of the present cone, since, doubtless, before the eruption of A.D. 79, the old great crater-rim was much lower on this than on the northern side. The remnant of the wall of the pre-historic crater on the southern side is the eminence called La Pedamentina, and this evidently formed a portion of the outside slope of the old crater wall, corresponding to the outside slope of Somma at the same elevation above the level of the sea. The hill of La Crocella, on which stands the Observatory and the Hermitage, is also a small remnant of the base of the bounding walls of the pre-historic crater separated from the main portion of what is left of it, the ridge of Somma, by the Fosso della Vetrana.

The escarpment or wall of Somma, extending for a distance of upwards of two miles, is more than a thousand feet high, and presents a face almost perpendicular. The upper edge is irregular in outline, and is, indeed, a serrated ridge or line of small peaks of more or less angularity.

Crater-rings of great diameter, like that of which Monte Somma is the remnant, are by no means rare, either amongst active or extinct volcanoes, and some are of dimensions far exceeding that of the old crater of Vesuvius. The great circular platform on which stands the present eruptive cone of Etna is doubtless but the surface of the infilling of such a great crater, and the summit of the Peak of Teneriffe is partly surrounded by what remains

of a crater that was no less than eight miles in its longest diameter. So, too, in the Isle of Bourbon the volcano there has a similar crater wall enclosing its present eruptive cone; while Madeira, St. Helena, and the Mauritius afford illustrations on an equally grand scale. The vast craters of Java and the Calderas of the Canary Islands are also conspicuous examples of these great craters that are, indeed, analogous to the enormous crater-rings which so conspicuously variegate the surface of the moon.

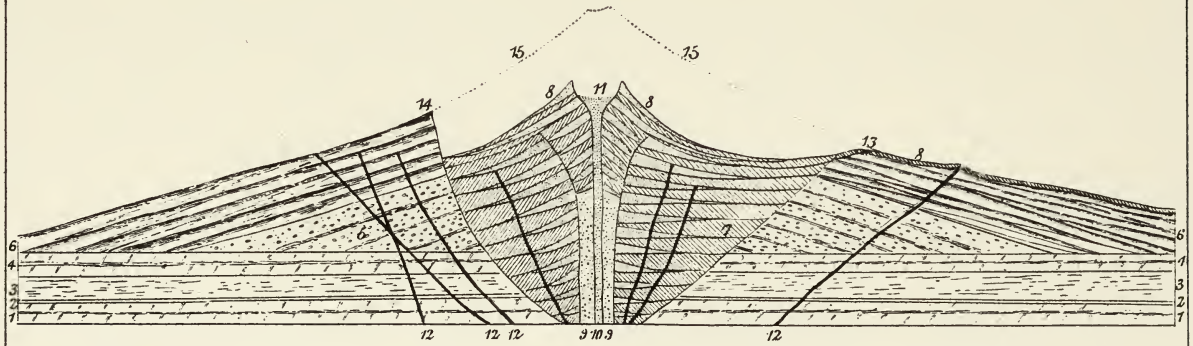
The formation of these vast craters is doubtless due to paroxysmal eruptions which have destroyed the upper portions of volcanic cones. Accounts of such destructive eruptions are numerous, for, in addition to the Plinian eruption of Vesuvius, there was an outburst in the Mollucas in 1638 that carried away an entire volcanic mountain of great size, and so completely that, instead of an elevation, a hollow was left, which, holding water, became a lake. Another eruption in the same region that destroyed one of the Molluca islands occurred in 1693. In the Leeward Islands, in 1718, a mountain was similarly entirely removed, and the extraordinary and well-known Javanese eruptions—that of Papandayang in 1772, and that of Sumbawa in 1865, as well as the recent one of Krakatoa—are instances of paroxysmal eruptions of similar destructive violence.

So enormous is the amount of material removed and distributed by these eruptions, that but for the

facts being indisputable they would be incredible. It must not, however, be supposed that these astounding results are produced by single explosions, but rather that they are the consequences of continuous and continued explosive force. As shown by Scrope, such an eruption cannot be compared, as thought by Humboldt, to the shock of an explosion of a mine or a steam boiler, but that the explosive energy "having once forced a communication with the open air, at the weakest point of some fissure broken by its expansive efforts through the overlying rocks, *blows itself out* through this opening by degrees, although with terrific violence; just as would the boiler of a high-pressure steam-engine of enormous dimensions and infinite lateral strength, when the valve of the steam-pipe, or an accidental aperture was opened—and *not* after the manner of a *boiler bursting, and discharging all its steam* at once, or of *an exploding mine of gunpowder.*"*

Unlike the craters of the Campi Phlegræi which are enclosed by cliffs of pumiceous tuff and by loose fragmentary materials, scoriæ and ashes, but like the modern crater of Vesuvius, the ancient crater was encircled by walls formed of successive layers of lava, alternating with beds of scoriaceous deposits, and traversed by dykes of basaltic rock. The various layers appear to be horizontal, but they are in reality not so, the appearance of horizontality

* Scrope's "Volcanos," edition 1872, pp. 206-7.



8. Modern & Recent Lava & Scoriæ Beds.
7. Infilling of Great Crater of A.D. 79.
6. Pre-historic beds of Scoriæ & Lavas.
5. Early Vesuvian beds, possibly submarine.
4. Tufas with marine shells, Post Pliocene.
3. Volcanic beds with marine shells, Post Pliocene.
2. Sandstones & Marls (Macigno) Eocene.
1. Apennine Limestone, Cretaceous.

15. Imaginary lines completing mountain when at its maximum.
14. Ridge of Monte Somma.
13. Pedamentina.
12. Dykes.
11. Crater.
10. Vent of ordinary Eruptions.
9. Vent of Paroxysmal Eruptions.

IDEAL GENERAL SECTION THROUGH VESUVIUS.

Plate XIV.

LONDON: ROPER & DRIVETT, 11, LUDGATE HILL, E.C.

being derived from the edges of the beds only being seen. These beds, or at least the lower ones, dip away from the exposed section at an angle of 26°, and so form the basis of the exterior slope of this side of the mountain, which has an inclination of about 30°, the increase of the angle of the exterior slope being attributable to the causes previously explained.

The dykes crossing and cutting through both the sheets of lava and the beds of scoriæ are generally nearly perpendicular, but they rise at all angles from 90° to 45°. A great similarity exists between the basalt of the dykes and the rock of the sheets of lava, the former, however, appears to be more homogeneous in texture.

The dykes of Somma have long been objects of interest to geologists, and must always remain so, since they are conveniently and prominently displayed on a grand scale, thus clearly revealing the internal structure of volcanoes, and while they illustrate the manner in which the fissures of volcanic cones become filled with solid rock, strikingly show the very large number of such dykes which exist in these cones. At Etna there is also evidence of the important part that dykes play in the formation of volcanic cones, for in the Val del Bove, the great valley on the side of the Sicilian volcano, so many dykes are exposed that it is seen that there, as at Somma, the aggregate amount of matter in the dykes forms a considerable proportion of the whole mass of the cone.

The obvious ultimate effect of the injection of fluid lava into fissures and its subsequent solidification into dykes is, besides that of strengthening the cone as previously said, an increase of the bulk of the solid materials of the cone. Thus a volcanic cone increases in size both by external and internal accretion, and hence its growth may be said to be, to apply botanical language to an unbiological subject, both exogenous and endogenous. Still it does not appear that the increase due to the formation of dykes is more than a tenth of the whole mass. The more frequent and the more violent the eruptions, the more numerous and the wider will be the fissures produced by the shakings of the mountain, and consequently the more numerous and more massive will be the dykes that will be subsequently added to the structure and bulk of the cone.

The lava-rocks of Somma are hard and compact leucitic dolerites of a bluish-grey colour. Many contain the mineral leucite in abundance, and not merely as a constituent mineral of the rock, but free and separate in the form of white embedded crystals, and these in great numbers. This is the distinguishing characteristic of these Somma rocks, for nowhere else do volcanic rocks display this mineral so conspicuously, although leucitic lavas were produced by the once active volcanoes of the Roman and some other volcanic regions, and the mineral is, perhaps, as abundant in some modern Vesuvian lavas. Leucite is a silicate of alumina and potash, is an

opaque white mineral with a specific gravity of 2·48, and is not quite so hard as felspar. It crystallises in the cubical or monometric system, and is often found here in detached and perfect trapezohedrons half an inch and sometimes more in diameter. (See Leucite, Chapter X.)

It is a remarkable and suggestive fact, that although so few minerals have been found in the modern lavas, or have been produced by the modern activity of Vesuvius, no less than 300 species of minerals have been enumerated as having been discovered in the ancient lavas of Monte Somma. The critical examination of these by Prof. Scacchi has, however, resulted in greatly reducing the number of distinct species. The variety and abundance of the minerals found associated with the rocks of Somma and their scarcity in the more recent products of the volcano very distinctly differentiate the pre-historic ejectamenta from that of modern times. Besides leucite, augite, hornblende, sodalite, and the other minerals found in the modern lavas, those of Somma yield vesuvianite or idocrase in beautiful crystals, olivine, humite, nepheline or sommite, garnets, apatite, aragonite, glassy felspar, &c. (See Chapter X.)

The Base.—This wide-spreading and almost circular mass underlying the Cone and the Ridge of Monte Somma, does not so conspicuously reveal its geological structure as the two upper portions of the mountain. Encrusted with sterile undecomposed

lavas on its upper, and covered with cultivated land on its lower surface, its interior is not exposed, hence recourse must be had to a large extent to inference.

Looking at the escarpment of Somma as a part of the wall of the crater of the volcano of which the present base was also then the lower portion, it is fair to assume that the upper part, at least, of this lower portion would be similar in character and structure to the immediately overlying portion of the same great cone. Thus we may conclude that the alternation of sheets of lava-rock and beds of scoriæ of which the face of Somma in the Atrio del Cavallo is composed continues downwards for some distance, and that such is the structure of the upper part of the wide-spreading base.

But whether the whole of this base is so composed, or whether the earliest portion is formed, like the hills of the Phlegræan Fields and the neighbourhood of Naples, of fragmentary materials or tufaceous deposits only, there do not appear to be any means of determining with certainty.

Vesuvius may have originated in a small cratered hill of scoriæ and ashes thrown up in a short time like Monte Nuovo; this may have received successive accretions from repeated eruptions of fragmental materials until it had attained fair proportions like Monte Barbaro or Astroni, though both of these cratered mounts were doubtless produced by single eruptions, and then subsequently emissions

of lava may have accompanied ejections of scoriæ. On this hypothesis, the core or nucleus of the base would be entirely composed of fragmentary materials, but would be covered over by a succession of beds of lava-rock alternating with beds of scoriæ and forming all the mountain above.

This hypothesis, however, rests on the assumption of the relative level of land and sea at this part of the Italian coast being the same at the origin of Vesuvius as now, and that the first ejection of volcanic material from the Vesuvian vent was on the land. But this is open to grave doubt, and it seems more probable that the vent was first active beneath the sea. Some of the upper lava sheets of Somma—that is, some of the later lavas of the prehistoric volcano—are found at Cisterna at about the sea-level, leading to the conclusion that the older flows or lower lava sheets of Somma are much below sea-level, and pointing to the early Vesuvius being a marine volcano, a short distance from the coast-line. If such were the fact, the lowest beds of fragmental materials, whether interbedded or quite unassociated with lava, would be consolidated by the action of the sea water into tufaceous rock similar to the tufa of Naples, though not necessarily of the same age. The oldest part of the mountain would then be submarine, but it would early rise above the waves, and continue to grow with successive eruptions, while an uprise of the sea bottom would uplift the entire base of the mountain, placing it on

the land, and forming a new coast-line outside the volcano.

But whether we regard the earliest Vesuvius as a submarine or as a terrestrial volcano, the fact must be recognised that it rests on older *submarine* volcanic beds.

At the artesian-well boring at the Royal Palace of Naples the fundamental sedimentary rock of the country, the Apennine limestone, was found at 1,560 feet below the surface. Above this was 153 feet of Eocene beds of sandstone and marls, called Macigno, and overlying these deposits about 700 feet of beds containing marine shells of recent species, which would indicate post-Pliocene or Quaternary age. Over these lie beds of volcanic tufaceous materials with marine shells, which reach the surface, and range under the city from 600 to 900 feet and upwards in thickness. This is, in fact, the tufa of which the hills about Naples and Pozzuoli are formed, and which spreads over the country in the interior, and this is the bed on which Mount Vesuvius stands. Volcanic action, therefore, ejected fragmentary matter, which was spread out by the sea, and consolidated into tufa long before the opening of the Vesuvian vent.

Thus it will be seen that Vesuvius is a comparatively recent volcano, and posterior to the post-Pliocene volcanoes that ejected the enormous masses of material that have been since sculptured into the hilly district at the back of Naples, attaining at the

hill of the Convent of the Camaldoli di Napoli the elevation of 1,483 feet above the level of the sea. The extensive ridge of Posillipo is also formed of this pre-Vesuvian volcanic material.

But though the commencement of the formation of Mount Vesuvius was in a very late geological period, the mountain has probably passed through many and varied phases, of which its present one, dating from A.D. 79, is but the latest.

From a lengthy and careful study of the geology of the whole mountain mass and its materials, Dr. Johnston Lavis has suggested the following

SCHEME OF THE ERUPTIVE ACTIVITY OF THE VOLCANO.*

Era A	Introductory paroxysmal stage—Problematical.		
Era B	Ancient chronic activity.	Phase I.	Chronic activity, outflow of lava with scoria, ash, &c.
Era C	Apparent extinction, interrupted by paroxysmal and other eruptions.	Phase II.	Inactivity. Denudation.
		Phase III.	Violent paroxysm dwindling into
		Phase IV.	Apparent return of chronic activity.
		Phase V.	Inactivity. Denudation.
		Phase VI.	Violent paroxysmal eruptions.
		Phase VII.	Less violent dwindling to
Era D	Modern chronic activity.	Phase VIII.	Chronic activity, outflow of lava, scoria, &c.

* The elaborate paper by Dr. Johnston Lavis on "The Geology

The concave outline observable in the profile of volcanoes, beautifully shown in that of the very symmetrical Fusi Jama in Japan, a mountain that may be regarded as a typical example of volcanic form, has been ascribed to a slight subsidence of the mass of the mountains, caused by the removal by the eruptive action of underlying material. It may be contended, however, that it is scarcely necessary to call in such a cause, since the more abundant formation of internal dykes and the more abundant fall of ejectamenta in the neighbourhood of the crater, together with the expansion of the foot of the base by the spreading out of the loose surface covering brought down by the gradual yet continuous descent of fragmentary material effected by gravitation and by the removing action of washing rains, sweeping storms, and eroding and transporting floods, would seem to sufficiently explain the phenomenon.

In the early part of the present century there was much discussion as to the manner of the commencement of volcanic cones. From his observations in the Canary Islands, and especially in Palma, in the year 1815, Von Buch was led to the conclusion that the walls of first-formed craters are the result of the uplifting of the rocks around a central point, the volcanic axis, and the subsequent bursting

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of Monte Somma and Vesuvius," published in the *Quarterly Journal of the Geological Society*, vol. xl., p. 35, should be consulted by those desiring a more detailed knowledge of the geology of the volcano.

through of the middle of the dome or blister so formed, by the volcanic eruptive energy. This view, with details of his observations in Palma and other islands, he published in a treatise entitled "Erhebung Cratere," or Craters of Elevation. The great Humboldt, from the formation of the remarkable volcano Jorullo in Mexico, in eruption in 1759, on a flat dome of lava, the "Malpais," favoured Von Buch's theory, and it had a wide popularity.

The many wide-cratered volcanic islands, the ridge of Monte Somma, and even Monte Nuovo, were regarded as illustrations in support of this hypothesis, and the formation of Jorullo was considered conclusive evidence. Poulett Scrope, however, closely examined the illustrations cited, and the arguments used, and then boldly attacked the crater-elevation theory. He showed that the Malpais was formed by a great emission of viscid lava on to a flat plain, which did not give a thicker mass at its highest point than some lava-flows in Iceland had produced, and that its maintenance of that thickness until solidification, in the middle part of the area, and its gradual declination around, was the result of the viscid character of the lava. Sir Charles Lyell supported Scrope by other observations, notably by those he made at Etna as to the greatest angle of inclination at which lava will solidify on a volcanic cone (see page 167). The result has been that the "Erhebung Cratere" theory is now obsolete, and volcanic cones are

regarded by geologists, both in their inception and their completion, as the simple result of the accumulation of ejectamenta solid or fluid, or both, around a central axis, the volcanic tube. The base of Vesuvius and the ridge of Monte Somma must therefore both be regarded as having been altogether so formed, a conclusion strikingly confirmed by the structure and history of the building up of the present eruptive cone.

Fig 1 Section through Vesuvius

Before the Eruption of A.D. 79.

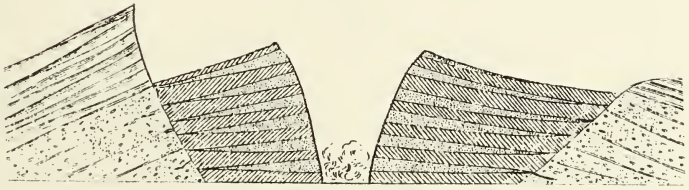


Fig 2. Section through Vesuvius

After the Eruption of 1631.

London; Roper & Drowley, 11 Ludgate Hill, E.C.

a mythological interpretation of all volcanic action. Classic fable abounds with allusions to volcanoes, associating them with Pluto, Proserpine, Vulcan, and Typhœus. Pluto seized Proserpine in Sicily, near to Etna, and carried her down with him to reign as his queen in his own dominions far below. Vulcan, the God of Fire and Fusion, the same as the Greek Hephæstus, forged the thunderbolts of Jove by volcanic fires, and the smoke, and flames, and bellowings, and shakings of an eruption were but the evidences of his industry. The Greek Typhon was the personification of the principle of evil, called by the Egyptians, Set, and described by the Latins under the name Typhœus, as having a hundred dragon heads, fiery eyes, a black tongue, and a terrible voice, and lying groaning and uneasy, buried under the volcanic regions of Sicily and Ischia, all obviously suggested by the volcanic character of those islands.

In mediæval times, superstitious dread of the crater of a volcano as an opening to the place for lost souls supplanted the mythological fables of the ancients, and even at the present day this supernatural association lingers amongst the inhabitants of volcanic regions. The denizens of the immediate neighbourhood of Etna so regard the crater, ten thousand feet above them, and think of it with mind-oppressing awe.

The renaissance in art preceded the renaissance in science, but just as Raphael and Michael Angelo

stepped into the footsteps of Phidias and Praxitiles, so did Bacon and Newton follow in those of Plato and Aristotle. The inductive philosophy of Bacon and its application by Newton paved the way for that widespread desire for the investigation of the operations of Nature that have produced in this century a Humboldt, a Faraday, and a Darwin. But however great may be the achievements of the nineteenth century, the preparatory work of the eighteenth it would be most unjust to lightly esteem. At the very beginning of that century, in 1700, Lemery ascribed volcanic phenomena to comprehensible causes, and seeing that rapid chemical combination, with evolution of heat, results from the contact of certain metallic with certain non-metallic substances, and building on the fact of the usual association of sulphur with volcanoes, suggested that below the surface stores of metals might be in juxtaposition with accumulations of sulphur, and from that contiguity such rapid and violent chemical action would ensue as would account for volcanic phenomena. It is easy to smile at Lemery's sulphur and iron filings illustration of his hypothesis, but that it was the best outcome of the science of the time is shown by the fact that it was not until the latter part of the century that another theory was advanced by any man of scientific repute.

Breislak propounded the somewhat similar hypothesis that bituminous masses, as petroleum and asphaltum, might exist in such association with

other substances that combustion would be the result, and subterranean combustion would produce volcanic effects. These were both obviously mere hypotheses, incapable of proof from actual observation of the phenomena displayed.

So, too, was the theory that, following those from France and Italy, emanated from England. The great chemist of the early part of this century will be chiefly known to fame as the discoverer of the bases of the alkaline earths, for to Sir Humphrey Davy we owe the knowledge that potash and soda are compounds of oxygen with the metals potassium and sodium, and that such is the eagerness of these metals for oxygen, that intense heat is the result of the process of combination. When Davy could rivet the attention and the interest of an audience at the Royal Institution by dropping a small piece of potassium on to the surface of a basin of water and so producing fire, it is not to be wondered at that he conceived the idea of the metallic bases of the alkaline earths being the cause of volcanic action. It was only necessary to suppose these existing in large quantities, deeply seated below the borders of seas from which water might pass, to postulate all the conditions necessary to produce the most violent volcanic effects. And such was the glamour of the great name of Davy, and so simple and probable did his hypothesis then appear, that it at once commanded great attention and almost monopolised assent; and not only so, but it long held the field

at a period when activity of scientific investigation, followed by abundant results, was a conspicuous characteristic of the time. So late as 1826, Dr. Daubeny, in his comprehensive work on volcanoes, stoutly advocated Davy's chemical hypothesis, and showed that all the usual gaseous products and emanations of a volcano can result from the contact of the "alkaline metalloids," to use Daubeny's phrase, with sulphur and the water of the sea.

It is curious to note that all three, Lemery, Breislak, and Daubeny, presuppose the existence of large amounts of native sulphur at the seat of volcanic action, whereas sulphur we now know to be a result instead of a cause of subterranean igneous conditions. Yet Davy and Daubeny gave prominence to the action of water, and thus approached the position taken up by later vulcanologists.

The remarkable persistence of contiguity or proximity to the sea of our present active volcanoes, and the contemporaneous extinction of volcanic activity in many areas with the emergence of adjacent lands from the sea, all directly point to the conclusion that water is an agent, and a great agent, in the production of volcanic excitement. The immense volumes of steam given off by fluid lava and evolved from crateral openings, with the great amount of common salt and other chlorides, support this conclusion. And indeed the phenomena of an eruption are so consonant with the action of superheated steam when intermingled with molten matter,

that vulcanologists, however they may differ as to the cause of rock-fusion, appear to be now agreed that water has much to do with volcanic activity. Grave and, to my mind, insuperable difficulties exist in explaining the method by which water can pass from the sea to a deep source of volcanic action, since open fissures would either not allow of water descending in the face of the steam that would force it back, or they would themselves be the channels of emission for the lava, and this would confine volcanoes to the sea bottom or marine areas; and the suggestion of capillary transmission, which has been called in to meet the difficulty, is equally unsatisfactory. For although the experiments of Daubrée showed that under certain limited conditions water can pass by capillary action through sections of rock in the face of steam, these conditions are not analogous to those that would obtain in intensely heated and deep-seated regions contiguous to volcanic foci. The Rev. Osmond Fisher has shown that such capillary passage of water cannot take place, and even if it could, it is impossible to believe that by this means such a rapid and abundant supply of water can be given as would provide the ejecting and explosive power of great eruptions.

But although no method for the supply of water to lava free from difficulty and entirely adequate to the circumstances and requirements of volcanic action in detail and in aggregate, has yet been

described by any of the advocates of the hypotheses which require water for the force that produces ejection of lava from its source, still the position and the phenomena as well as the products of volcanoes leave no room for doubt that to water is due violent volcanic eruptive effects.

The questions of the *source* of the lava, of its *fusion*, and of the *cause of the requisite heat* are not, however, so generally agreed upon.

For a long time the widespread opinion that the earth consists of a thin shell or crust enclosing an interior mass in a state of fusion, sufficed to account to most for the emission of the lava of volcanoes, which indeed was regarded as a proof of a fused interior. This belief, however, did not by any means entirely rest on the outpouring by volcanoes of fluid rock material from the interior of the earth, but also on the fact deduced from many mines, sinkings, and borings, that the temperature of the earth increases with depth below the surface. The rate of increase varies in different localities, but it is usually stated as being 1° for each 60 feet of descent (though the Rev. Osmond Fisher gives it at 1° for each 51 feet of descent) below about 100 feet from the surface.

At this rate of increase the temperature at a mile below the surface will be 150°, always supposing continued uniformity of augmentation, at two miles about 240°, at five miles 500°, at ten miles 940°, and at thirty miles a temperature of 2,700°, a greater heat than is required for rock fusion, so that were

the conditions the same as those on the exterior of the globe, there would be fused rock at a depth of thirty miles from the surface.

M. Cordier, the most prominent advocate of the thin-crust and fused interior hypothesis, carried out very elaborate calculations, and estimated that a contraction of the radius of the earth to the extent even of the $\frac{1}{1250}$ of an inch would suffice to press out through any opening in the crust the amount of lava produced by a volcanic eruption, and that a similar contraction of a millimetre, or ·03937 of an inch, would cause the exudation of lava sufficient for 500 of the greatest known volcanoes.

Careful consideration, however, of the physical requirements of a vast revolving globe of fused matter, and the consequences of its being enclosed and retained by only a thin exterior shell, has led to the general, though not universal, abandonment of the hypothesis, and consequently to the disassociation of volcanic lava from a great central fluid mass.

The elaborate calculations and arguments of Mr. Hopkins and Sir William Thomson led those physicists to the conclusion that a thickness of at least 800 miles must be given to a crust adequate for the satisfaction of cosmical conditions, and although Sir William Thomson subsequently (1876) abandoned his method of calculation and its extreme results, it has been sufficiently established that a thin crust, such as Cordier supposed, around a vast interior fused mass nearly 8,000 miles in diameter

would be too flexible to be as rigid as it is while subjected to the attractive influence of the moon and the sun, and that as one result, among others, there could be no marine tides. A much thicker crust is, therefore, required, but any such sufficiently thick solid rocky mass would render impossible the egress of lava, which often issues in very small quantities. Indeed, when we consider what a single mile of solid rock means, thicker than the height of any mountain in the British Islands, it scarcely needed the authority of Mr. Mallet to assure us that with 400 miles even he believed "it may be proved, on various grounds, hydraulic amongst others, that neither water could reach the nucleus nor the liquid matter of the nucleus reach the surface."

The similarity of volcanic products all over the world was long a favourite argument on the side of the common central source hypothesis, but when it is remembered that the great rock masses all over the globe are composed of the same few chemical elements, it is not difficult to understand why the results of the fusion of these similarly composed rocks should be themselves similar.

Central heat of high intensity is admitted, however, by all, for not only is it consonant with, and indeed required by, the nebular hypothesis of the formation of the solar system, with the present condition of the sun, and with the secular cooling of the earth, but it is pointed to by the already mentioned general and continuous increase of heat with descent

below the surface. That increase of heat does not produce fusion at a depth where fusion-heat may be expected, is accounted for by the increase of pressure consequent upon greater depth from the surface. Water passes into steam at different temperatures according to the pressure of the atmosphere, at 212° at ordinary sea-level pressure, at 193° at the diminished atmospheric pressure of 10,000 feet elevation, and, conversely, water under great artificial pressure can be raised to a very high temperature while still retaining its liquid form. So also the change from solidity to liquidity obeys the same law, and therefore solid bodies under great pressure retain their conditions of solidity at temperatures much higher than would suffice for their fusion under less pressure. Thus the increase of heat with depth may be consistent, it is contended, not only with a very thick solid crust, but even with a continuously solid interior nucleus. Should, however, at any part of a sufficiently highly-heated interior region, pressure be removed, or sufficiently lessened, the hindrance to fusion would cease to exist and solid rock would become at once fluid lava.

Thus have modern vulcanologists accounted for the production of the sources of volcanic outpourings, giving as the cause of the removal or diminution of pressure the local elevation of the uppermost crust, or the fracturing or giving way of rocks below volcanic areas. The names of distinguished vulcanologists are associated with this hypothesis, which

has reigned as the most favoured one during the last thirty or forty years.

As an outcome of this view, more or less permanent reservoirs or underground lakes of fluid lava are assumed to exist, where pressure has been removed or diminished, and into which sea-water finds its way, causing, by the resulting super-heated steam, violent ebullition, which elevates a portion of the fluid mass above the surface of the earth, when with the explosive escape of the steam violent volcanic phenomena are produced.

To the existence of such permanent extensive lakes of fused rock there are, it seems to me, the strongest objections, for the temperature of the molten mass must be the temperature appropriate to its depth, and therefore the same as the temperature of all the materials at its level, or distance from the surface of the earth, and consequently of the bounding walls of the fiery lake. But there will be as little pressure on those walls as on the fluid mass, and so they must also pass into the fluid state, and as more and more of the surrounding solid mass became liquefied there would be fresh rock surfaces brought into conditions favouring fusion, and so the subterranean reservoir would continually be enlarged by the liquefaction of surrounding solid rock, until so great and widespread a cavity would be produced, and such an enormous mass of melted rock would be accumulated, as would speedily bring about a catastrophe greater than the world has ever seen.

If there were any vacuity from the discharge of a portion of the mass with a vent for evolved gases, there would be a falling in of the overlying roof with all the area above, and if there were no vacuity the expansion consequent upon the change from the solid to the liquid condition of such a vast quantity, together with the production of gaseous compounds and super-heated steam, could neither be satisfied by a mere comparatively minute volcanic vent, nor by an insensible rise of land, but only by the bursting upwards of the roof of the great reservoir, and the consequent destruction of a large portion of the earth's surface.

The hypothesis of removal of pressure and the consequent liquefaction of rock with the formation of reservoirs of lava, did not find favour with the late great English seismologist and vulcanologist, Mr. Mallet, who, in 1872, brought before the Royal Society a paper "On Volcanic Energy: an Attempt to Develop its True Nature and Cosmical Relations," and in the next year published his views in "An Introductory Sketch" to his translation of Prof. Palmieri's "Eruption of Vesuvius in 1872."

Mr. Mallet shows that internal movements are not the result of forces primarily vertical proceeding radially, but are, as stated by Constant Prevost, "tangential pressures acting horizontally, and resolved by mutual pressures at certain points into vertical resultants." To these pressures, consequent upon the shrinkage from cooling of the solid crust of the globe,

are to be therefore attributed the elevation of mountain chains which went on with much greater rapidity while the crust was thinner than at the present time when the solid portion of the globe is very thick. Nevertheless, contraction is still going on, and produces tangential pressures, which, not being now so readily resolved into vertical movements, are transformed into heat, computed by Mr. Mallet to be far more than all the volcanic heat we know, and "that making large allowances for presumably defective data, less than one-fourth of the total telluric heat annually dissipated (represented by 777 cubic miles of ice melted) is sufficient to account for the annual volcanic energy at present expended by our globe." Thus, to use the words of the author of the hypothesis: "We see here linked together as parts of one grand play of forces, those of contraction by cooling, producing by *direct* mechanical action the elevation of mountain chains, and by their indirect action, by transformation of mechanical work into heat, the production of volcanoes; and both by direct and by indirect action, of earthquakes, never previously shown to have thus the physical connection of one common cause, but merely supposed, more or less, to be connected by their distribution upon our earth's surface."

Such is a very brief statement of an hypothesis which from Mr. Mallet's life-long investigation of scismic and volcanic phenomena is entitled to great respect. One objection is that

it does not seem to employ the great heat it assumes to exist at great depths apart from that produced by lateral pressure, and which on that diminution of pressure that must locally result from foldings, however slight, of overlying strata must act in the direction of fusion. And it is difficult for me to understand, though I have not seen this objection stated, how tangential pressure can be transformed into heat at particular points or along particular lines for many centuries with the result of the fusion and emission of vast aggregate amounts of material without, while the pressure is still going on, surface derangements being produced on an extensive scale. The Rev. Osmond Fisher has shown, too, that the heat produced by crushing pressure cannot be sufficiently localised to produce fusion, but must be by conduction disseminated through a large surrounding region, and so be inoperative for the effect claimed. And I would venture to say that the elevation of land as shown by the geology of the great mountain ranges was by no means small in late geological times, when the crust of the globe must have been similar in thickness to what it is at present from the palæontological evidence of similar climatal conditions.

Indeed, it may here be added that palæontological evidence, showing, as it does, similar life-forms in Cambrian and Silurian rocks to those now living, clearly proves that not widely dissimilar climatal and general cosmical conditions from those at

present obtaining, prevailed also in the Palæozoic Period. Thus the conclusion is irresistible that throughout the three great geological periods—the Palæozoic, the Mesozoic, and the Cainozoic—there has been no very great change in the amount of heat given to the surface from the interior of the globe, and consequently it may be safely assumed that during this vast lapse of time the thickness of any "crust" overlying an internal fused mass cannot have materially altered.

To overcome the difficulties of the hypothesis of a thin crust with the whole of the interior of the globe a fused mass, Dr. Sterry Hunt suggested a solid, very large nucleus, surrounded by a sea of re-fused material, impregnated with water from the exterior, surrounding and enclosing which is the solid crust of the globe of moderate thickness, and through cracks and fissures in this the fused matter would rise to the surface, as was supposed by Cordier.

There was still the difficulty of the passage of water to the lava below, and this was insuperable to the Rev. Osmond Fisher, who, believing that the increase of temperature with depth may be depended on to give a rock-melting temperature at 30 miles, accepted Dr. Sterry Hunt's central solid nucleus (solidified by pressure) and an inter-layer of fused matter, under the exterior crust (solidified by cooling), but advanced in his "Physics of the Earth's Crust" the bold hypothesis that the steam given forth by volcanic lavas is the result of an extravasation of a

primogenial "water substance" in the molten matter of the earth's interior, and not derived from the sea or from surface water at all.

This view resembles the more circumscribed one of Prof. Tschermak, who held that gaseous ejections at volcanic vents are portions of the original constitution of the magma of the globe, and that to their escape the activity of volcanic vents is due.

A still later hypothesis is that of Prof. Prestwich, who, in his recently published work, "Geology," states his adherence to the opinion that the source of the lava of volcanoes is below the crust of the globe, which gently presses upon the fluid mass in consequence of continued slow cooling, and so forces the lava through whatever vents may exist, but that the water of volcanic eruptions is derived in the first place from land surface water and subsequently from the sea after the lava has risen in the volcanic vent. In the concluding portion of this hypothesis, Prof. Prestwich approaches an opinion I have myself for some time held—namely, that the water of volcanic action is met with by the lava not far below the surface; but I cannot agree with the learned Professor either as to the source of the lava, the cause of its rise in the volcanic tube, the importance of land surface water, or the secondary and subordinate place assigned to sea water.

Neither can I agree with Prof. Dana that deep-seated water may be a constant force and surface

water a secondary force, since I do not believe there is any deep-seated water at all—that is sufficiently deep to approach the neighbourhood of any established volcanic focus.

To summarise my objections to these various hypotheses, I may say that I am opposed to—

1. A common infra-crust source of lava.

2. The passage of what are comparatively insignificant quantities of lava through 30 miles of rocks, and consequently through all greater thicknesses.

3. The ejection of lava from its source by vertical pressure.

4. The ejection of lava from its source by steam, or "potential steam," force.

5. The passage of water through deeply-seated hot rocks, whether by open fissures or by capillary transmission.

6. The accumulation or the presence of water at volcanic foci.

7. The primogenial "water-substance" source of volcanic water.

8. The importance of land surface water.

To justly estimate or adequately appreciate the value of any theory or hypothesis, it is necessary, before all things, that the facts to be accounted for should be fully recognised and constantly borne in mind. I have accordingly prepared a statement of the leading and controlling facts connected with volcanoes and volcanic phenomena. While endeavouring to make this compendium sufficiently

comprehensive, I have stated each of the facts briefly, but, it is hoped, clearly as well as concisely, and the whole have been numbered for facility of subsequent reference.

COMPENDIUM

OF THE CHIEF FACTS CONNECTED WITH VOLCANOES AND VOLCANIC PHENOMENA.

1. The outputs of volcanic eruptions relatively to the bulk of the globe are individually infinitesimal, and in their aggregate form only a small part of even the visible surface of the earth.

2. Astronomical calculations, ocean tides, and the general stability of land and sea during long periods, demonstrate great rigidity of the solid exterior of the globe, and consequently a great thickness of solid rocky substructure.

3. There is no general constant flexibility or mobility of the earth's exterior, each subsidence or upheaval being confined to a certain area, and limited to a certain period, while some subsidences and upheavals are confined to very small areas, as those of the Bay of Baiæ.

4. The general inorganic and climatal conditions of the earth's surface were generally similar in Palæozoic to those of Neozoic times, as shown by similar organisms, ripple-marks, worm-burrowings, rain-pittings, &c.

5. Palæozoic volcanic action does not appear to have been greater than Neozoic, and the highest

mountain ranges of the globe have received a large amount of their present elevation since the close of the Secondary Period.

6. The specific gravity of the whole globe is only 5·5, while that of cognisable rocks is over 2·5, although Waltershausen calculates the pressure at the centre to be equal to 2,498,600 atmospheres, and Laplace, 3,000,660.

7. Heat has been found to increase with distance from the surface at a rate that if continued would give rock-fusion under atmospheric pressure only, at from 25 to 30 miles (in some areas the rate of increase is greater), and at half the distance to the centre a temperature equal to that of the sun, an impossible heat. There is, therefore, not a continued uniform increase of heat.

8. Rock-fusion, resulting from simple relief of vertical pressure in subterranean regions where the heat is sufficient to fuse rocks under surface conditions, would not be limited in lateral extension if there is an open vent, and surface depression and derangements with consequent lava outputs on a scale far transcending any terrestrial catastrophes that have occurred would result.

9. Volcanic action has gone on for long periods of time in many areas without causing any surface derangements, except the building up of cones, or the rupture of very small areas.

10. Areas of great volcanic activity in Palæozoic and even in Tertiary times, although still contiguous

to the sea, are, and have been, through immense periods of time perfectly unvolcanic, as the Southern Hebrides; and insular volcanoes in more recent times have become quite extinct without change of geographical conditions, as in Madeira and the Canary Islands.

11. Lavas from different volcanic regions, though having a general resemblance, are not the same in composition, and some present considerable differences.

12. Lava solidifies with a small loss of heat, small quantities solidifying rapidly, and many lava-flows are very inconsiderable in volume.

13. The products of the same volcanic centre at different periods may be respectively trachytic and augitic, as those of the Alban Hills; or may be characterised by different mineralogical features, as those of the Somma-Vesuvian centre; while trachytic and augitic lavas may respectively characterise two vents in the same volcanic region, as in the Neapolitan.

14. A sequence of volcanic rocks has been detected, and may be stated as follows, according to Richthofen: I. Propylite (Earliest). II. Andesite. III. Trachyte. IV. Rhyolite. V. Basalt (Latest), or, in other words, the earlier lavas of the same volcanic centre are usually trachytic or acidic, and the latest lavas augitic or basic.

15. Sudden eruptive energy may occur where no volcanic vent previously existed, in some cases

followed by a continuance of activity, as at Jorullo, and sometimes after a brief outburst, followed by perfect quiescence, as at Monte Nuovo.

16. Two volcanic craters on the same dome may not be sympathetic in activity, as Kilauea and Mauna Loa.

17. The eruptive axes of volcanoes sometimes vary their position, as in Vulcano and Vulcanello.

18. The volcanic foci of Etna and Vesuvius were calculated by Mallet to be only a few miles deep.

19. There are permanent hot springs in non-volcanic districts, indicating long-continuing, uniform, and considerable heat at no great depth, as at Bath, Clifton, and many other places.

20. The chief Northern European Tertiary volcanic outpouring, that of the lavas of Antrim, Iona, Staffa, and Mull, was in the same geological epoch as the great Central European *subsidence*, that of the Alpine region; and the great Central European Tertiary outpouring, that of the lavas of Auvergne, central Germany, Bohemia, and Hungary, was contemporaneous with the principal Central European Tertiary *elevation*, that of the Alps.

21. Volcanic action generally is in rising rather than in subsiding areas.

22. Volcanoes, though sometimes in groups and sometimes isolated, have by far their greater number arranged in linear extension, and this is round the chief water area of the globe, the Pacific Ocean, marking the commencement on their eastern and

western sides of the great land masses, and coinciding with a line of elevation on the crest of which the volcanic vents are situated.

23. Active volcanoes, with few exceptions, are either in the sea (insular or sub-marine), or are on coasts either contiguous to or at but little distance from the sea.

24. Inland extinct volcanoes were near the sea, or sea-like lakes, at the period of their activity, as in Auvergne and Hungary.

25. The extinction of volcanic activity has followed the removal of the coast-line to a very moderate distance, as in the Roman Campagna.

26. Steam is a most abundant and sea-salt a prominent product of explosive eruptions, and all the elements of sea-water are contained in the ejectamenta of explosive volcanoes, while some volcanic tuffs consist largely of marine Diatomaceæ, as in Patagonia.

27. Nitrogen and various chlorides occur as volcanic products.

28. Volcanic phenomena seem to be absent from oceanic or deep-sea bottoms.

29. Some eruptions are altogether explosive, as those of Vesuvius in A.D. 79, Monte Nuovo, and the recent one of Krakatoa; while some are altogether non-explosive and merely quiet emissions of lava, as those of Mauna Loa.

30. Neither Daubrée's or any other experiments have shown that water, either by capillary trans-

mission or by fissures, will pass through massive rocks bordering on a fusion-temperature.

31. Enormous flows of lava have occurred without explosive effects, and there are vast beds of lava-rock that have not been, when fluid, associated with any volcanic cones, as in Antrim, Abyssinia, and Idaho.

32. Plutonic igneous rock-beds and dykes have been formed without explosive effects.

33. The volcanic tubes of the non-explosive craters of Mauna Loa and Kilauea are surrounded by solid, always hot, lava-rock, and in the products of these craters chlorides are rare.

34. Volcanoes quite dormant for many centuries have, some, commenced a new epoch of activity, as Vesuvius; and, sometimes after one eruption, have relapsed into complete quiescence, as Epomeo.

35. "Eruptive action is characterised by spasmodic fitfulness" (Geikie), and frequently the most violent eruptive phenomena are exhibited at the close of a lengthened period of Strombolean activity.

36. "When explosive force is spent lava rises in vent" (Judd).

37. Feeble volcanic action may continue for centuries without change, as at Stromboli and the Solfatara.

38. Pressure caused by shrinkage of the earth's crust is tangential, not vertical.

39. The heat produced by crushing pressure of rocks is not localised at the points of contact, but

disseminated through the rock masses synchronously with production.

40. Observations of the activity of Stromboli and Vesuvius seem to indicate an approximation to periodicity of eruptive energy coincident with—(1) Autumn and Winter, (2) the Lunar Syzygies, and (3) with hygrometric atmospheric conditions.

41. 2,000,000 tons pressure are removed from every square mile of the earth's surface when the barometer falls two inches.

42. Vegetable remains have been present in volcanic mud and water, and fishes, such as live in the local caverns, ejected; while remains of fresh-water diatoms were found by Ehrenberg in volcanic rocks of the Rhine, and in the Island of Ascension.

43. Immediately before or at the commencement of eruptions the water in neighbouring wells falls, and the sea recedes, followed by a returning wave.

44. Antecedent to eruptions, earthquakes, earthquake shocks, or earth tremors occur, especially and more violently previous to the opening of new vents, as Jorullo and Monte Nuovo, and after long dormancy, as before the first historic eruption of Vesuvius.

45. Though great volcanic activity may be noted at particular periods, yet sympathy between the eruptive energy at any two well-separated vents has not been found with certainty to exist.

The difficulty of finding a theory to which some one or other of the foregoing facts is not

at variance, must be obvious; and there is little wonder, therefore, that opinions widely differ, or that the discussion of the cause of volcanic action seems to promise to be well-nigh interminable. Still it should be borne in mind that some of the most eminent observers, thinkers, and logicians amongst geologists have made vulcanology a special study, with the result that a very great amount of data has been accumulated, forming, we may hope, an approximately complete and firm foundation on which to build the long-desired conclusive superstructure of this branch of geological science.

The sister branch, Seismology, has, during the last fifty years, made great advances through the continued and assiduous observations and researches of Mr. Mallet, and more recently of Prof. Milne, in Japan, and both of these authorities have brought their special knowledge and experience of earthquakes to the elucidation of volcanic phenomena. Prof. Palmieri and Dr. Lavis are patiently watching every phase of Vesuvian action; a seismic observatory, like that on Vesuvius, has been established on Etna; and not to mention foreign savants, Prof. Judd has specially visited various volcanic regions to obtain facts and make observations that might throw light on the question. We are, therefore, now in a much better position than ever before to obtain a satisfactory solution, and it may be confidently hoped that as far as is possible from the nature of the subject, the matter may soon be set at rest.

As a contribution to a settlement of the question, I brought before the British Association, at the recent meeting at Bath, conclusions, arrived at after many years' attention to the subject, which appear to me to be more consonant with observed phenomena and known facts than the hypotheses previously advanced. While here giving these conclusions as then stated, I can in this work do no more in support of them than appeal to the facts stated in my "Compendium," but this appeal is made with some degree of confidence that the facts and the hypothesis will not be found to be altogether antagonistic.*

A. The primary cause of the formation of fluid lava, it seems to me, is the internal heat of the globe inducing chemical, and possibly electrical, action in subterranean regions where the chemical composition of the rocks and their contained and associated minerals are favourable, and when, moreover, the conditions become more favourable by the removal of the restraining vertical pressure of the superincumbent rock masses by the counteracting lateral

* The paper "On the Causes of Volcanic Action," containing my views, and their advocacy in brief, was read in the Geological Section of the British Association at the Bath meeting on September 10th, 1888. An abstract giving the conclusions appeared in the *Times* of Sept. 11th, and one more lengthy in *Scientific News* of Sept. 14th, as well as in the "Report of the British Association for the Advancement of Science for 1888," page 670. The paper was also read at the meeting of the Geologists' Association of London on December 4th following, and has since been printed *in extenso* in the "Proceedings of the Geologists' Association," vol. xi., page 1.

or tangential pressure produced by secular cooling causing shrinkage.

In this view there is room for the operation of chemical combination and electrical and magnetic influence, induced by a degree of heat not nearly sufficient for ordinary rock-fusion, that consequently may exist at such a moderate depth as not to render impossible the passage of small ejections of the resulting lava through vents in the overlying rocks. In other words, a moderate heat may induce, where there are suitable materials and conditions, such chemical and other action as will produce sufficient additional heat to cause rock-fusion, which will necessarily be confined to the region and the period where and when the suitable materials and conditions exist.

This hypothesis is founded on the doctrine that chemical re-actions favoured by fusion may be restrained or prevented by a pressure that raises the fusion-point of temperature, and that when the liquefaction of substances fusible at low temperatures is effected, changes are initiated that will produce sufficient heat to fuse the more refractory substances with which they may be in contact. That, in fact, fluxes exist and operate in Nature's laboratory as well as in the furnaces of man.

It appears to me that this hypothesis fulfils the requirement of Sir Charles Lyell when he says in his "Principles of Geology," "It is only necessary, in order to explain the action of volcanoes, to discover

some cause which is capable of bringing about such a concentration of heat as may melt one after the other certain portions of the solid crust, so as to form seas, lakes, or oceans of subterranean lava."

I am not prepared to deny, however, that water may be present, and, too, as an agent of reaction, where and when that chemical action commences which produces the greater heat that brings about rock-fusion, but after rock-fusion has commenced, and a lava source has been established, I cannot believe it to be possible for water to approach such a source.

Nor can I understand how water, after acting as an oxidiser, can remain in any form to take part in the ejection of lava. If the water has given up its oxygen to combine with bases, it can no longer be water, and only hydrogen will remain. The enormous volumes of steam given forth from explosive eruptions would remain to be explained. True it is that M. Fouqué reports considerable quantities of hydrogen as given forth from eruptions, but the amount is altogether insignificant when compared with that of the watery vapour, the whole of which being undecomposed has had nothing to do with any chemical re-combinations that may have taken place.

B. The ejection of lava from its source, and its rise in a volcanic tube or conduit, is due to the expansion caused by the change from the solid to the liquid state (comparable with the rise of mercury

in the tube of a thermometer from increased liquidity), together with the production of potentially gaseous compounds from chemical reactions amongst the many compounds forming, and accessory to, the mass of the magma, favoured by the fused condition.

This rise of the lava in the volcanic tube may be influenced by meteorological conditions, as the position of the top of the column of mercury in the tube of a barometer is affected by the weight of the atmosphere, and the meteorological effect may be supplemented by lunar attractive influence. Thus it appears to me the lower or plutonic part of a volcanic tube is a thermometer and subsidiarily a barometer, and to use a new word, an *helkusometer** (or measure of attractive influence) combined.

C. The explosive features of volcanic eruptions I hold to be altogether secondary, and that these as well as the determination of the position, and to some extent the distribution, of volcanic vents to be due to the sea, the water from which, conveyed by interstitial percolation through cool or not highly heated rocks, pours into the comparatively cool upper portion of fissures or old volcanic conduits, together with that derived from ordinary land surface sources.

This water, converted into steam by its descent to heated lower depths and by the approach of ascending lava, causes by its expansive and explosive power the opening of rents admitting large

* From ἕλκυσίς-εως = attraction.

and sudden flows or gushes of sea-water to the lava conduit, which may have receptive expansions at but moderate depths where water may have accumulated, and thus the conditions are produced that occasion the greater explosive effects of violent eruptions.

Simple emissions of lava without ashes or explosive phenomena are due to the absence of water except in small quantities, such as may be derived from the surface or from the rain or snow on crateral openings. The non-explosive simply lava-emitting character of the Hawaiian volcanoes is explained by their conduits being surrounded by water-excluding always highly heated though solid lava.

Purely explosive and ash eruptions are explained by the introduction of water into a fissure partly filled with lava which does not reach the top of the tube, and which, by cooling and solidification, if the fissure be a branch one, may effectually and permanently seal it, and so prevent any further eruption at that point, as in the case of the single-eruption cratered ash-cones of the Phlegræan Fields.

The actual volcano I consider to be due to the sea, which, by giving its water in sufficient volume when lava is ascending, produces that explosive and rending force that opens a vent at the surface and adds a volcano to the globe, and thus is explained that wonderful association of volcanoes with the sea that so markedly characterises their distribution.

CHAPTER IX.

VOLCANIC PRODUCTS.

Vesuvian Products largely representative—Similarity and Dissimilarity of Volcanic Products—Descriptive Catalogue of Volcanic Products—Ejected Blocks, with List of Fossils.

THERE are not many volcanic products unrepresented in the Vesuvian area, as the result of either the pre-historic or the later eruptive activity of its volcanic focus and vent, and therefore in the following pages these few have been included. The list given is, consequently, one of volcanic products generally.

It is perhaps otherwise desirable to give here such a comprehensive enumeration, since however much the materials produced by volcanic action may differ among themselves, in the aggregate they possess a striking similarity, in whatever part of the world they may be studied, and hence forms of volcanic ejectamenta unrepresented in a particular area may nevertheless be most usefully illustrative of those forms that are there produced, and may, moreover, afford indirect evidence of considerable value in the study of vulcanology.

The general similarity of volcanic products from remotely separated regions cannot be, according to the hypothesis stated in the last chapter, a matter for wonder when it is remembered that the known

rocks of the globe are almost entirely made up of about a dozen mineral substances only, and that these are composed of about the same number of chemical elements. For it is fair to assume, and to a geologist the conclusion is inevitable, that the materials of the surface regions of the earth are in their chemical composition, in the aggregate, similar to those of the underlying masses, and that, therefore, the rocks far below the surface will be generally similar in all parts of the globe, and that if similar substances, under similar conditions, are subjected to the same agency, heat, the resulting products will be generally similar.

On the other hand, the dissimilarity existing amongst volcanic products may also be easily explained, for though but few chemical elements or mineral substances make up the great mass of the rocks, yet there are not a few other elements existing in these rocks, in certainly but a small proportion, but in by no means inconsiderable quantity, and these are very irregularly distributed. Although, therefore, the general conditions on which volcanic products are based are similar, still sufficient local diversity exists to account for the varied chemical and physical characters of volcanic ejectamenta.

Descriptive Catalogue of Volcanic Products.

Allogovite.—A form of basalt, occurring in the Allgau, of a grey, or reddish colour, with labra-

dorite intimately blended, and named as a distinct rock by Winkler.

Amphigenite, Cordier, called also Leucitophyre.—A name given by Cordier to augitic lavas in which leucite, either wholly or in part, takes the place of labradorite. Such is the ancient lava of Monte Somma, and such are the modern lavas of Vesuvius. In the Roman Campagna this rock is seen at the Capo di Bove, on the Appian Way, about two miles from Rome and near the tomb of Cecilia Metella, where it is quarried. It is also to be found in the German volcanic district of the Eifel. At Somma the leucite has separated itself very distinctly, forming fine complete trapezohedrons as large as nuts, and these in great abundance. The rock is here not so dark in colour nor so heavy as that of the Capo di Bove, where it is very compact, hard, and dark-coloured, with small grains only of leucite embedded in the augitic mass. Of the modern leucitic lavas of Vesuvius some contain much more of the mineral than others.

Etymology: From amphigene, from ἀμφί, on both sides, and γένος, origin, a name for leucite.

Amygdaloidal Dolerite.—Amygdaloid is the name applied to rocks having almond-shaped cavities either empty or partly or wholly filled with crystalline minerals, and may be used adjectively to describe such a rock, or given as a name for the rock itself when plutonic. Amygdaloid volcanic rocks, however, frequently occur, as was shown by Von Buch,

in the Canary Islands. The almond-shaped cavities have been produced by evolved gases when the mass was in a fused state, and the elongated form of the cavity is the result of the motion of the fluid mass, the larger diameter being in the direction of the movement. The sparry or crystalline contents of the cavities have been subsequently deposited from infiltrated solutions.

Etymology: From ἀμυγδαλα, an almond.

Analcymite (Cyclophyre).—A basic rock of the Cyclades, two-thirds of the mass of which is made up of Analcime filling up fissures and cavities. It may be, in the opinion of Von Cotta, an altered Nepheline Dolerite.

Anamesite, Von Leonhard.—An augitic or pyroxenic massive lava closely allied to basalt and dolerite. It is similar in composition, but not so fine-grained as basalt, and not so conspicuously granular as dolerite.

Andesite, Von Buch.—Andesite, from its rough texture, was thought to be a form of Trachyte from the volcanoes of the Andes, consisting largely of a sanidine felspar; but it is now known that the prevailing felspar is plagioclastic, allied to oligoclase but containing more lime, and named Andesine. Some Andesites contain free quartz, to which the name Dacite is given, and those without quartz are divided by Mr. Harris Teall into Augite-Andesite, Eustatite-Andesite, Hornblende-Andesite, and Mica-Andesite.

Besides the Andes, Abich says the Caucasus and Mount Ararat are localities where Andesite occurs.

Etymology: The name is from the Andes, the mountains in which it chiefly occurs.

Ash, Volcanic.—Volcanic Ash is the fine black dust or sand that falls on the surface after an eruption. It is first carried upwards with the volumes of ascending steam which it darkens, and so produces the "smoke" of a volcano. It is sometimes carried to a very great height, and forms with the steam an overhanging canopy, from which the larger and heavier particles first fall and cover the surface of the mountain-top, and the smaller are carried in the direction of the wind and gradually fall, the finest dust being borne along to the greatest distance. This dust is sometimes carried by the upper currents of the atmosphere to very long distances, and crews of ships far from land are apprised of an eruption by finding on the decks a deposit of volcanic ash.

After the Krakatoa eruption in 1883 there were for a long time remarkably coloured sunset glows both in Europe and America, and it has been contended, especially by so eminent an authority as Norman Lockyer, that these were produced by the extremely fine volcanic ash from Krakatoa, retained as suspended particles in the upper regions of the atmosphere. Some of the Krakatoa ash was actually found in Europe.

This black dust is evidently the result of the trituration of fragmentary ejectamenta produced by

the repeated explosions in the volcanic vent, and has been found by microscopical examination to correspond in composition with the lava of the same eruption. The eminently leucitic lava of 1871, when artificially reduced to powder, was found by Prof. Palmieri to perfectly resemble the volcanic ash then ejected.

When washed with water the ash loses by solution some constituents, of which the principal is sea-salt, but there are other chlorides and free acids. This offers an explanation of the destructive effect of volcanic ash, and of the rains which pass through it, on vegetation. When the tender tops of plants are watered by a solution of Vesuvian salt they soon afterwards wither. Some years ago the young leaves of the oaks of Sussex were found, after a violent south-west gale, to be withered, and this blight, which was very conspicuous in the early summer, was attributed to the salt of the sea borne inland by the spray-charged wind.

In 1872 "white sand" fell on a part of Vesuvius, presenting a striking contrast to the black surface around. Some of this, collected by Palmieri, was found in a few days to be coated with red, and mingled with green particles. On examination the white grains, which had their angles rounded, proved to be leucite, and the green particles augite or pyroxene, while the red coating on the white grains was "a deposit of organic matter."*

Basalt.—Basalt is a name equally applicable to

* Palmieri's "Eruption of Vesuvius in 1872," p. 120.

massive lavas of recent and of long-past geological times. It is a fine-grained, heavy, dark, sub-crystalline rock, composed of augite, labradorite, plagioclase (or nepheline), and magnetic peroxide of iron, often with olivine. The term has been rather loosely used to designate massive lavas generally, but it is now restricted to the finest-grained or most compact solidified lavas, lava-rock of a coarser texture being called Anamesite, and when still coarser, Dolerite.

Basalt is amorphous, tabular, and globular, but its most characteristic condition is columnar, which is very decided and conspicuous. The columns may have three, four, five, six, or eight sides, but they are usually hexagonal, and fitting so closely together that it is sometimes difficult to insert a knife between them. They range from 5 to 150 feet in height, with a diameter from 3 to 18 inches, and are often divided horizontally by semi-spherical joints—that is, the bottom of one section of a column has a convex surface fitting in a concave top of the section below.

The Giant's Causeway of the North of Ireland, and Fingal's Cave in the Isle of Staffa, offer perhaps the best-known examples of columnar basalt in the British Islands, and furnish excellent illustrations of the hard and durable character of the rock, as the edges of the columns, exposed though they have been to the action of the waves for ages, are still quite perfect.

Etymology: The name is from basal earth, used by Pliny, meaning "iron earth," since basalt often contains much iron.

Bombs, Volcanic.—Volcanic bombs are the rounded, usually ovoid, and partly vesicular masses of solidified lava that are after ejection from the crater precipitated on the slopes of a volcano. The rounded symmetrical form is doubtless due to the mass of lava of which they are formed being in a soft, semi-solid state at the time of ejection, which would allow of an irregular form being reduced to a compact rounded one by the rotation of the masses during their passage through the air previous to cooling and entire solidification. Volcanic bombs are usually from six to twelve inches in diameter, though some have been found of a much greater size.

Cinders, Volcanic.—Volcanic cinders are scoriaceous fragmentary lava of irregular form and size, but not flattened like the scoriaceous cakes formed on the surface of lava-flows, and are intermediate in size between volcanic bombs and lapilli. They are usually vesicular, and frequently have surfaces coloured with deposits of sublimed compounds. Volcanic cinders are, in fact, the medium-sized fragments ejected from the volcanic vent, and largely make up the loose material partly composing the surrounding cone. Their production is due to the volcanic explosions ejecting to a moderate elevation small portions of fused lava which in their flight through the air evolve gases giving the

THE LAVA OF 1858, SHOWING SURFACE PRODUCED BY THE SOLIDIFICATION OF SLOWLY-MOVING LAVA.

(From a Photograph.) *(Judd's Volcanoes.)*

vesicular structure while gradually cooling and solidifying.

Dacite.—This name is given to Andesite in which is disseminated free quartz.

Dolerite, Harris. — Dolerite may be briefly described as a coarse-grained basalt, since it is a solidified lava of augite or pyroxene, labradorite, and magnetic peroxide of iron. It is sometimes amygdaloidal, and sometimes porphyritic, the distinct crystals in the latter case being either felspar or augite.

Ordinary recent lavas on the flanks of a volcano may usually be described as Dolerites, while the massive lavas of unusually great flows are best described as Basalts or Anamesites. Thus the ropey and wavy solidified lavas in the Atrio del Cavallo and on the Piano of Vesuvius are doleritic, and the thick-rock masses of the lava of 1631 at Torre del Greco and Resina are basaltic. Mr. Harris Teall gives the following as varieties: Olivine-Dolerite, Eustatite-Dolerite, Mica-Dolerite, and Hornblende-Dolerite.

Dolerite is from δολερος, deceptive, from the difficulty of seeing its constituent minerals.

Domite.—Domite is a trachyte with an earthy rather than a harsh or rough feel. It is greyish-white in colour, and resembles an impure chalk. Domite, as its name indicates, is the peculiar rock of the Puy de Dome and the other extinct volcanoes of Central France, which, issuing as a very viscid

lava, has produced in some cases cones without craters. The felspar, of which Domite chiefly consists, appears to be oligoclastic, instead of orthoclastic sanidine, from which this rock has been named Oligoclase Trachyte (see Trachyte).

Etymology: The name is from the "domes" of the extinct volcanic region of Auvergne, in Central France, of which the Puy de Dome is one, where Domite is characteristic.

Flame.—Although volcanoes are popularly called "burning mountains," and flaming fire is commonly supposed to characterise all eruptions, it is only to a very limited extent true that actual *flame*, or incandescent gas, is produced by volcanic activity. The fiery glow and illumination of the clouds of steam and ashes, and of the sky, which form the grand and perhaps the most impressive feature of a volcanic eruption, are simply due to the reflection of the incandescence of the lava below, and not as a rule to flame at all.

Still it cannot be doubted that true flame is sometimes produced, and, too, in some cases perhaps conspicuously. Even if old accounts be disregarded, the very positive statements of modern observers cannot be set aside. In his description of the eruption of Etna in 1838, Mr. Gladstone says he saw a "sheet of flame which leapt up with a sudden momentary blast, and soon disappeared in smoke." * So great a scientific authority as Sir

* "Etna," by G. F. Rodwell, p. 58.

Humphrey Davy has reported flame, and Giuscardi, Abich, and Pilla have confirmed the report. Professor Pilla states that he saw from the edge of the crater of Vesuvius during the eruption of 1833 a column of flames. "It rose," he goes on to say, "to the height of four or five yards, and then disappeared among the volumes of smoke, so that a person whose eye was on a level with the edge of the gulf could not have seen it. Hence it is that the existence of flame has been so confidently denied. The flame which I observed was of a decided violet-red colour."

That this is not constantly the case inside the crater at the time of an explosive eruption, I can affirm from my own observation of the interior of the Vesuvian crater during the eruption of 1868 while standing on its rim, the same position as that occupied by Prof. Pilla at the time of the eruption of 1833. I then certainly saw, although it was a very bright day, a considerable illumination of the dense white fumes that filled the interior, but there was no *flame*, not even at the moment of an explosive discharge of ashes and bombs.

The flames, however, which it must be admitted are sometimes observed, are doubtless due in the main to discharges of hydrogen gas, which burns in air, as is well known, with but a faint flame.

Fulgori.—See Lightning, Volcanic.

Gases.—The fumes of a volcano, although consisting chiefly of watery vapour, contain several

gases which, except when absorbed by water, retain the gaseous condition. Of these, perhaps the most abundant is hydrochloric acid and then sulphurous acid gas. After these, chlorine, hydrogen, and carbonic acid gas in a later stage of eruptive action, and less abundantly nitrogen, hydrofluoric acid, and sulphuric acid. The last-named in its anhydrous or gaseous state is very rare.

HAÜYNOPHYRY. — This is a basic rock of the Monte Vulture Volcanic Region, consisting mainly of augite and haüyne, but containing also olivine, mica, and leucite. The haüyne appears to be the mineral that takes the place of the labradorite of ordinary dolerite. The well-known volcanic rock of Niedermendig, on the Rhine, which has been used for millstones for ages, contains haüyne conspicuously.

LAPILLI.—Lapilli is a frequently used word to designate small volcanic ejectamenta, smaller than "volcanic cinders," and not so fine as "volcanic ash." It is most usually pumiceous, and it is then generally considered to be trachytic in composition. Perhaps the best example of lapilli is that of the material now being cleared away from the streets and houses of Pompeii. This is a light grey pumiceous lapilli made up of fragmentary ejectamenta ranging from the size of a pea to that of a small orange, though specimens 8 inches across, it is said, have occasionally been found.

Etymology: Latin *lapillus*, contraction of *lapidulus*, diminutive of *lapis*, a stone.

Lava.—Lava is the most common word used in connection with volcanoes and volcanic eruptions, and is the name used for both the fluid fused rock emitted by a volcano, and the solidified stony masses that result from its cooling. In this place, however, only the fluid will be referred to, solidified lava being described under the various names that have been given to its varieties, as dolerite, anamesite, basalt, trachyte, domite, &c.

Though lavas from all parts of the world have a general resemblance in being fused rock, and have a generally corresponding mineralogical composition, in consisting mainly of silicates, yet they vary so considerably that their chemical composition is widely different, and their specific gravity as well as their colour and other physical characters when cooled not less so. They usually agree, however, in having a felspar as a principal constituent, but the two groups into which lavas generally are divided are characterised by two different felspars. These two groups are the augitic and the trachytic, called so in the one case from its characteristic mineral, and in the other from the character of the rock it forms when cooled ; or the basic and the acidic, from the relative proportions of their basic and acidic constituents.

The lava now usually seen and spoken about is augitic or basic, and is composed of augite, called also pyroxene, a lime felspar such as labradorite, olivine, and iron oxide, though in the Vesuvian

lavas leucite to a great extent replaces the felspar. Augitic lava, consisting as it does of two and sometimes three silicates, has a large proportion of basic material, alumina, magnesia, lime, potash, &c., and has a specific gravity of 2·85 to 3·10, which is much more than that of the ordinary surface rocks of the globe. It is also, when cooled, dark-coloured or black.

The following, from Roth's "Petrographie der plutonischen Gestein" (1869), gives the composition of Vesuvian lavas of the great eruption of 1631 and of the eruption of 1867-8 :—

	1631.		1867-8.
Silica	46·41	.....	46·94
Alumina	19·67	.....	21·35
Peroxide of Iron ...	6·88	.....	7·27
Protoxide of Iron ...	4·17	.....	4·96
Magnesia...	5·23	.....	3·78
Carbonate of Lime ...	10·53	.....	9·69
Soda	2·02	.....	0·62
Potash	4·09	.....	5·57
	99·00		100·18

The other type of lava, the Trachytic, mainly consists of a potash felspar or orthoclase, and is much lighter in weight, and when solidified usually much lighter in colour than the augitic lava. Its composition gives it so much silica or silicic acid as to justify the name acidic applied to trachyte and its varieties.

The temperature at which lava fuses is greatly affected by its composition, that containing the greater proportion of basic constituents being more readily fusible, but ordinary augitic lava fuses at

about 2,000° Fahr., the temperature, too, at which ordinary plutonic rocks melt.

There is also a great difference in the liquidity and viscidity of lavas, those of the Hawaiian craters being perhaps the most mobile of all, flowing and spreading rapidly over the surface, and solidifying at a very low angle. These lavas have also the property of being very ductile, so much so, indeed, that they are drawn out by the wind into very fine threads, forming filamentose lava called "Pele's Hair" (which see). One of the Vesuvian lavas, that which flowed during the eruption of 1855, was especially fluid, flowing in a narrow stream a long way into the cultivated region; and it was found to contain an unusual compound called "Cotunnite," a chloride of lead, to the presence of which the abnormal liquidity was attributed. The more leucite, too, there is in a lava the more mobile it appears to be, and the more easily the filamentose condition is produced. Such lava is remarkable for forming on its surface when cooling in a lava-flow a continuous skin instead of a covering of loose fragmentary scoriæ, and consequently the rapidity of movement *over the same decline*, and the character of the cooled solidified surface product, indicate to some extent the mineralogical and chemical composition of the fluid mass. The Vesuvian lava of the eruption of 1867-8 was one of the least fluid of the augitic lavas, moving very owly, and forming scoriæ abundantly.

Trachytic lava is less fluid and mobile in character than the augitic. So viscid, indeed, is trachytic lava sometimes that it refuses to flow after exudation and maintains a mound-like form, as in the case of the "Mammelons" of the Isle of Bourbon. The great dome-like volcanoes of Central France, on the summit of which there are no crateral hollows, are formed of solidified trachytic lava, to which the name "Domite" is given.

The colour of fluid lava changes like that of melted iron. When issuing from a "bocca" it is a bright light yellow, then it gradually becomes a richer yellow, then orange, and finally when solidifying a dull red, like red-hot iron. With these changes of hue there is also a gradual increase of viscidity, and so great does the consistency become before the end of a flow is reached, that stones thrown upon the surface scarcely make an impression.

The low heat-conducting power of lava is remarkable, and sometimes produces curious effects. It is often possible to stand on a solid black surface and through the chinks see underneath the red-hot lava, while deep and wide flows may have a solid crust that may be walked over for months, while at some distance below the lava is still quite hot. Tunnels formed by the solidification of the surface of lava-flows have been several times mentioned, and strikingly attest the slow conduction of heat by lava.

The name "Lava de fuoco" is locally given to

lava to distinguish it from volcanic mud, which is termed "Lava d'Acqua."

The material used for cameos, &c., in the Vesuvian district is locally called "lava," though it is not lava at all, never having been in a fused state, and being simply limestone altered by the volcanic heat.

Etymology: The Neapolitan word *lava* primarily means a torrent of water overflowing and washing the streets, from the Italian *lavare*, to wash (same as the Latin), from which it was applied to the streams of fluid matter descending the slopes of Vesuvius.

Lava d'Acqua, see Mud, Volcanic.

Lava de Fuoco, see Lava.

Lightning, Volcanic (*Fulgori*).—Frequent observations of lightning, or electrical manifestation, in the cloud of smoke produced by volcanic eruptions leave no doubt whatever that this is not the ordinary lightning of meteorology, but is entirely due to electricity consequent upon volcanic action.

An ingenious apparatus by which the electricity of eruptions can easily be studied was devised by Prof. Palmieri and installed at the Observatory. It is named by the Professor "Apparachio a conduttore mobile," or apparatus with movable conductor, and possesses a bifilar electrometer of great delicacy. Palmieri says: "The Observatory is distant in a direct line from the central crater of Vesuvius 2,380 metres, so that, when the smoke is copious, it is properly situated for the study of electricity, parti-

cularly when the wind inclines the pine-tree cloud in the direction of the Observatory, as frequently happened on the last occasion (1872). With smoke alone, without ashes, we obtained strong tensions of positive electricity; with ashes only, which sometimes fell while the smoke turned in the other direction, we had strong negative electricity; when the smoke inclined towards the Observatory, accompanied with ashes and lapilli, we had sometimes one kind of electricity, and sometimes the other, just as the smoke or the ashes predominated; and often with a fixed conductor we obtained negative electricity, and with a 'movable conductor' positive electricity."

"The conditions under which ('fulgori') lightning flashes are seen from the cloud of smoke are that it is conveying great abundance of ashes. In 1861 there were small flashes even from the line of eccentric mouths above Torre del Greco, although the smoke was not very great; and when these ceased to discharge, and the central crater became somewhat active, with a moderate amount of smoke but a great deal of ashes, small and frequent lightning flashes were observed in the twilight darting through the smoke, which was dark in colour." *

Liparite.—See Trachyte Porphyry.

Masenga.—This is a name given to the Trachyte of the Euganian Hills, in Lombardy.

* "The Eruption of Vesuvius in 1872," by Prof. Palmieri. Translated by Robert Mallet, pp. 130-31.

Mud, Volcanic.—In South America and other parts of the world there are ejections of a sulphurous mud of a fœtid and offensive character, to which the name "volcanic mud" is given. But volcanic mud may also be produced by ordinary volcanoes discharging great volumes of steam that condensing, cause floods of water which converts the smaller ejectamenta of the same eruption into a thin mud. This descends the mountain slopes and deluges the lower grounds and habitations, sometimes causing more devastation than the lava-flows. Such was the manner in which Herculaneum was overwhelmed and destroyed, and its ruins are now imbedded in the consolidated and indurated volcanic mud of the eruption of A.D. 79. To the mobile mass the name "Lava d'Acqua" is locally given.

Nekrolite.—The name given by Brocchi to the Trachyte of the neighbourhood of Viterbo and Tolfa in the Roman Volcanic Region.

Nenfro is another of Brocchi's names for a local Trachyte, that of the Cimini Mountains.

Nepheline Dolerite.—A variety of Dolerite in which nepheline, or sommite, takes the place of labradorite. It has, like all the Dolerites, a crystalline granular texture, and consists essentially of augite and nepheline, with as accessories titanite sanidine, olivine, and acicular crystals of apatite. First distinguished by Von Leonhard.

Obsidian.—Obsidian is a vitreous form of acidic lava, and closely resembling dark-coloured bottle

glass, it is often called "volcanic glass." So like glass is it in the hardness and sharpness of its edges, that in Mexico and Peru cutting weapons were made of it by the natives. Only when thin is it semi-transparent. As it is the result of a rapid cooling which does not allow of the formation of a crystalline structure, it can be artificially imitated by melting and casting, as was done with the Rowley Rag, an igneous rock of Staffordshire, for economic purposes, but as this was a basic rock the vitreous product of the fusion was rather Tachylite than Obsidian.

Etymology: The name Obsidian is from "Obsidianus lapis," stone of Obsidius, a name used by Pliny in honour of Obsidius, the reputed discoverer of the rock in Ethiopia.

Pele's Hair.—This is a filamentose form of the very fluid lava of Mauna Loa and Kilauea, in Hawaii, produced by the wind catching the jets of the hot lava as they rise from the surface of the fiery lakes in the craters, and blowing it in fine silk-like threads on to the rocks around. On several occasions similar filamentose lava has been found in the crater of Vesuvius, especially after flows of highly leucitic lava.

Etymology: From Pele, the name of a goddess of the Sandwich Islands.

Peperino.—Peperino is a variety of tufa formed by the aggregation of small fragments of a somewhat varied character, which give to it the peculiar

partly rounded granular structure suggesting its name, which is from the Latin *pifer;* Italian *pepe*, *pevere* = pepper, in allusion to the peppercorn appearance of the materials of which it is composed.

Perlite (Pearlstone).—This richly siliceous rock consists of a compact matrix with a somewhat pearly lustre, containing imbedded spherical grains having sometimes a concentric structure, and often showing crystals of several minerals, as sanidine, mica, garnets, and occasionally quartz. Perlite in all its varieties is most conspicuously developed in the volcanic districts near Schemnitz, in Hungary. Beaudant names the following varieties: Granular Shelly Perlite, Sphærutitic Perlite, Perlite-Porphyry, Vitreous Perlite, Argillaceous Perlite, Pumiceous Perlite.

Phonolite, or Clinkstone. — Phonolite, called also clinkstone, is trachytic in composition, but not so in structure. It is compact, smooth, and fissile or slaty, while chiefly consisting of a potash felspar, and contains usually a disseminated zeolitic mineral. It varies in colour, but its most general tint is a bluish-grey, in some cases much darker than in others. The character by which it is best known is its sonorous quality of giving a somewhat metallic sound, or clinking, when struck, and arrangements of different toned stones of this rock have been made to form a musical instrument called the rock-harmonicon.

Etymology: φωνε, sound, and λιθος, stone.

PITCHSTONE.—Pitchstone is a vitreous acidic lava, not so glassy as Obsidian, but, as its name implies, with a considerable likeness to solid pitch, having a conchoidal fracture and a dark colour admitting of chromatic variations. Under the microscope, minute crystals of felspar may be detected. Though Pitchstone is usually classed amongst the plutonic rocks, it is conspicuously displayed as a volcanic rock in the Isle of Ponza, where it has a prismatic and globiform structure.

POZZUOLANA.—Pozzuolana is a name that was used in old times to designate the volcanic tufa of the neighbourhood of Pozzuoli, which was extensively used as a material for cement and shipped in large quantities from the port whence it takes its name. Its cementing properties are due to its chemical composition, and render it valuable for hydraulic cement or that which sets under water, and it is said that the original "Roman cement" was made from this material. The so-called "Roman cement" of England is manufactured from the septaria of the London Clay.

PUMICE.—Pumice is a highly porous and consequently very light volcanic material of a pale grey or a light straw colour. It has so little specific gravity that it floats on water, and after the eruption of Krakatoa, in Java, in 1883, it covered the surface of the sea to such an extent that ships sailed through it for long distances. The pores or vesicles being longitudinal, the substance has

a somewhat fibrous appearance, and having a softly rough texture it is very useful for smoothing purposes and much used for removing old surfaces of paint.

From its lightness both in weight and colour, pumice has been considered to be essentially trachytic and almost altogether composed of orthoclase sanidine felspar. It is now found, however, that in some instances it may be augitic, and that its pumiceous characters are due to its structure. The peculiar structure and texture of pumice is doubtless produced by the evolution of gases in the mass of fluid lava, together with an ebullition causing a surface froth of the upper portion of the lighter and more viscid lava, which is broken up and ejected in solidified fragments. Lyell's definition is: "A light spongy lava chiefly felspathic, of a white colour, produced by gases or watery vapour getting access to the particular kind of glassy lava called Obsidian when in a state of fusion. It may be called the froth of melted volcanic glass."

Etymology: Latin *pumex–icis*, the name given by the Romans to the substance, originally *spumex*, foam, from *spuo*, to spit.

Rhyolite. — The name Rhyolite is used to designate the ultra acidic volcanic rocks or those containing a larger percentage of silica than ordinary trachytes, and is thus made to include Trachyte Porphyry, Perlite, Obsidian, and Trachytic Pumice.

In the Rhyolites free quartz is found much oftener than in Trachyte, while Amphibole and Pyroxene are much more rare. Von Cotta's definition of Rhyolite is: "A compact, enamel-like, or vitreous matrix, enclosing grains or crystals of sanidine, oligoclase, mica, or even quartz. Specific gravity 2·3—2·6, silica 67—82 per cent."

SCHIUMA.—Schiuma is a local Campanian name for the smaller cindery ejectamenta analogous to lapilli, the word meaning froth, foam, scum, dregs, impurities, dross.

SCORIA.—Scoria is a comprehensive name for the rough, irregular, cindery, and vesicular fragmentary ejectamenta of a volcano, and more especially for the cooled fragmentary material from the surface of small lava-flows. The surface of these streams, chilled by contact with the air, becomes, near their termination, covered with cakes more or less vesicular and rough, which fall over the end of the flow or from its sides, and are therefore flattish masses of moderate size, eighteen inches and under across.

Etymology: Latin *scoria*, from Greek σκορια, from σκορ = ordure.

SMOKE, VOLCANIC.—The so-called smoke of a volcanic eruption is chiefly composed of steam and the fine black dust called volcanic ash (which see), and accordingly the various proportions of this black dust, intermingled with the ascending steam, determines the various shades of blackness or

darkness of the smoke. Thus it is that when the explosive features of an eruption are not very pronounced the smoke is whiter, and when explosive phenomena prevail the smoke is darker in colour.

When the weather is calm, or when there are but light winds, the column of smoke after ascending to a great height with little or no expansion, then spreads out horizontally, and so the whole assumes a form usually likened to a pine-tree. During some eruptions the smoke ascends to an enormous height, several times that of the volcano. In the case of Vesuvius, three times its height is mentioned by Sir William Hamilton as the elevation attained during the eruption of 1779, and in the great eruption of 1822 the extreme elevation is stated to have been four or five times the height of the mountain. In the photographic representation of the comparatively recent eruption of 1872, the smoke or column of ash-charged vapour is clearly shown to have been three times the height of the crater above the level of the sea, or upwards of 10,000 feet.

Steam.—It may perhaps be said that steam is the greatest of volcanic products, for no eruption—that is, no explosive eruption—occurs without producing immense volumes of watery vapour, which, given off in gigantic puffs, form an ascending column of great height, and a canopy-like expansion above of great magnitude. And even lava emitted tranquilly from a volcanic cone gives off clouds of steam that quite

cover and hide the flowing and glowing mass of red-hot lava.

Sublimations.—Sublimations are found on the walls of the crater, on the summit of the cone, on the sides of fissures and "bocche," in the cracks and chinks of lava, but especially around the fumaroles of volcanoes. They are deposited from fumes which arise from the lava, and which have been produced in it by the vaporisation by heat of various chemical compounds. The sublimations of Vesuvius are numerous, abundant, and sometimes very conspicuous by their bright and varied colours. Red, blue, green, yellow, and white variegate what would otherwise be a dark and sombre surface. So dappled over and adorned with bright colours, the surface of the summit of the cone is sometimes very beautiful. Some of the sublimations collected by myself twenty years ago are now as bright in colour as when first deposited. The emanations of the fumaroles of the tranquil lavas of long and moderate Vesuvian eruptions appear to have a certain sequence, which is stated to be as follows: 1st, watery vapour; 2nd, sea salt; 3rd, oxide of copper; 4th, hydrochloric acid; 5th, sulphuric acid, and afterwards chlorides or sulpho-chlorides, and sometimes sulphides, which give soda, magnesia, copper, lead, and traces of other substances. On lavas of great eruptions, chloride of iron is sublimed with the above-named compounds, and this changes their appearance.

On small lavas the action of sulphuretted hydrogen with sulphurous acid deposits crystals of sulphur, and distinct crystals of sal-ammoniac, tenorite, and cotunnite are also found. Micaceous peroxide of iron (ferroligiste), though common near eruptive cones, is only found on lava when transported from the crater. Palmieri is of opinion that the chlorides are sometimes derived from the oxides.

Tachylite, Breithaupt.—As obsidian is the vitreous form of the acidic volcanic rocks, so Tachylite is the vitreous form of the basic or doleritic class. It accordingly, while resembling obsidian in its general glassy appearance, is augitic in chemical composition. The Rowley Rag, a basic igneous rock of Staffordshire, when artificially fused, produced a Tachylite.

Etymology: ταχυς, quick, and λίθος, a stone, from reference to the quickness with which it fuses under the blowpipe.

Tholeite.—A rock consisting of, according to Bergemann, 70 per cent. of labradorite, 5 of pyroxene, 3 of magnetite, 9 of carbonate of lime and protoxide of iron, and 11 of an undetermined silicate, and which may therefore be classed with the dolerites. Von Cotta, however, appears to doubt whether this rock may not be a plutonic rock, and allied to the melaphyres. The rock is at the Schaumberg, near Tholei, whence the name was given to it by Steininger.

Trachy-Dolerite, Abich.—An intermediate rock

between the acidic and the basic, containing, in some varieties, only 52 per cent. of silica, though the usual range is from 57 to 62. Von Cotta says of it that it is "a compound of oligoclase (or labradorite) with hornblende or augite, some magnetic iron ore, and frequently also mica. These minerals lie imbedded in a grey or brown matrix." The hornblendic trachy-dolerites are to be found at the Peak of Teneriffe, among the older lavas of Etna, and on the island of Liscanera, near Stromboli, while the augitic or pyroxenic rock occurs on the central cone of the Rocca Monfina.

Trachyte, Haüy.—Trachyte is at the head of one of the two divisions of volcanic rocks, since it is the typical acidic rock in which silica forms so large a proportion of the whole. It is usually mainly composed of orthoclase-felspar in the form of sanidine, and its chemical composition as given by Abich is as follows: Silica, 67.09; alumina, 15.64; potash, 3.47; soda, 5.08; lime, 2.25; oxides of iron, 4.59; magnesia, 0.98; oxide of manganese, 0.15; titanic acid, 0.38; water, &c., 0.45. It forms sometimes very large masses of rock, and so viscid has its lava been in some cases that it has exuded and retained its mound-like form, and so produced a dome-like elevation without a crateral opening.

The colour of trachyte is usually grey, and the texture rough to the feel, which justifies its name. This roughness of surface is due to a minute porphyritic structure, small crystals of felspar being

disseminated through the mass, and sometimes there are to be found crystals of pyroxene, amphibole, or mica. The following have been included by Von Cotta under the name Trachyte: Sanidine trachyte, sanidine-oligoclase trachyte, oligoclase trachyte or domite, andesite, trachy-dolerite.

Etymology: τραχυς, rough, in allusion to its roughness of feel.

Trachyte-Porphyry, or Liparite.—This rock and its varieties are richer in silica and consequently more acidic than the trachytes proper, and the group has been defined by Von Cotta as follows: "Trachyte-Porphyry is the name given to those rocks (prevalently felsitic and porphyritic with a compact matrix) which are geologically allied to the trachytes." Sometimes crystals or grains of quartz or mica, or both are imbedded. The varieties defined are six, with silica forming from 67 to 81 per cent., and having a specific gravity of 2.4 to 2.6. The varieties as given by Von Cotta are: Common trachyte-porphyry, perlite-like trachyte-porphyry, argilo-trachyte-porphyry, vesicular or millstone porphyry, pumiceous trachyte-porphyry, and slaty trachyte-porphyry.

Trass.—This name is given to very extensive deposits of Tufa in Germany, in the neighbourhood of the Rhine, and especially well seen near Andernach and in the valley of Brohl. Its striking similarity to the Neapolitan tufa was pointed out by Dr. Daubeny, who showed that it was antecedent in

age to the great deposit of fresh-water marl in the Rhine valley and of marine deposition, while being the product of the now extinct neighbouring volcanic craters. It contains fragments of pumice and also of non-volcanic rocks, such as clay-slate, and has imbedded in it carbonised trunks of trees. In one place land-shells have been found, but their occurrence may be due to an after valley-wash.

Tufa, or Tuff.—Tufa, or Tuff, is an agglomerate of small fragmentary materials of volcanic origin compacted together by the agency of water. It is various in its cohesion, and also in its composition and colour, but it is never so hard that it cannot be called a soft rock, while it is usually hard enough to constitute a useful building material, when overcoated with some kind of stucco, and thus it is largely used in and about Naples. At Naples and its vicinity may perhaps be found the most typical tufa, which there forms not only the hills to the north and east, but the site of the city itself. The Neapolitan tufa has been well described by Dr. Daubeny as follows: "Its basis is generally of a straw-yellow colour, dull and harsh to the feel, with an earthy fracture, and commonly a loose degree of consistence. It contains imbedded fragments of pumice, obsidian, trachyte, and many other varieties of compact as well as cellular lava, the softer kinds often rounded, the harder mostly angular." This tufa is chiefly trachytic, and its materials have been deposited in the sea, as shown by the presence in it

of the shells of the Mediterranean mollusca. It is in its structure and constitution, therefore, a marine "mechanically-formed" rock of volcanic materials, and such appears to be a correct description of tufas in many other localities.

Amongst tufas of an analogous character to that of Naples, perhaps the one most resembling it is the rock in the neighbourhood of the Rhine in the district of the Eifel, to which the name Trass is there given (which see), and which is especially thick near Andernach.

The tufa of the Roman Campagna and of the "Seven Hills" of Rome is somewhat similar, though this appears to have been compacted by the action of fresh-water, in which the volcanic materials were deposited. The Roman tufa is of two kinds, called by Brocchi the *lithoide* and the *granular*. The former is more compact and of a dull red colour, and forms the Capitoline and Esquiline Hills, while the latter, the granular, a fresh fracture of which gives a granular surface, is yellow, brown, or dark violet, and is seen in the Pincian and Quirinal Hills.

Another tufa is formed by the condensation of the watery vapour given off at an eruption causing a flood on the slopes of a volcano, by which the ejected ashes are converted into a mud that may be deposited, and afterwards consolidated on the lower ground around. Such is the character of the tufa in which the ruins of Herculaneum are imbedded. (See Mud, Volcanic.)

Since lapilli and ashes, which constitute the material of tufa, may be either doleritic or trachytic, it is obvious that the mineralogical and chemical composition of tufas must be various, but as lapilli is usually pumiceous, and pumice is usually trachytic, the majority of tufas are in the main trachytic, though frequently containing particles and crystals of augite, and in Italy and the Eifel leucite, with small fragments of mica, olivine, hüyine, &c.

Etymology: *Tufa*, Italian name for a porous stone, from Lat. *tophus*, the name for the rock tufa.

Ejected Blocks.

A notable addition to ordinary volcanic products is furnished by Vesuvian ejectamenta, and it is therefore perhaps better to place this class of the products of volcanic energy, Ejected Blocks, separately. These masses, shot forth in a solid form from the Vesuvian vent at various periods, and now found imbedded in the fragmentary materials of the mountain, are of great importance and value, both as showing the character of the underlying rocks of the volcano, and as being the repository of many of the Vesuvian minerals. They consist of both non-volcanic and volcanic material, for very many are blocks or fragments of limestone, an essentially aqueous or water-formed rock, and all have been torn from the platform or foundations of the mountain by the eruptive forces, and thrown out of the central vent of the period by great or

paroxysmal eruptions, the explosive energy of which has been too great to be restricted within the circumference of the normal volcanic tube. These ejected masses are very various in size, many being small fragments, smaller than an orange, some the size of cocoa-nuts, and many much larger, ranging to large and heavy blocks, such as one seen in a section the face of which, when measured by Lavis, was found to be about 6 feet 6 inches by 9 feet.

As will be seen from what has been said of the underlying rocks of Vesuvius, the limestone that is so conspicuous in the Apennines, and is seen as a surface rock as near as Castellamare and Capri, is the bed-rock of the whole of the volcanic beds and elevations of the Neapolitan Volcanic Region. It is from this rock that a large proportion of the Ejected Blocks are derived, but the effect of the volcanic heat has been sufficient to, in many cases, convert the rock from a coarse limestone, which the Apennine Limestone is, to a marble-like limestone as fine in texture as are the ordinary marbles of Italy. It is this altered limestone that is used for cameos and sold as "lava." It is, too, in the cavities of these changed, or, as geologists say, metamorphosed masses, that occur many of those rare minerals that distinguish the Vesuvian area. Some, however, of the ejected calcareous blocks are almost, if not entirely, unaltered from their original condition of coarse limestone.

Some of the Ejected Blocks are fragments of the

Tertiary Macigno which overlies the limestone, and some are portions of the super-imposed rocks of Post Pliocene age on which the mountain stands. From these non-calcareous fragmentary masses, some sandstone, some marl, and many tufa, have been derived the fossil shells which so clearly prove the geologically late commencement of the volcano, and which, with the exception of one, the *Buccinum semistriatum,* Broc., are all now living in the adjacent sea. In the year 1773, Sir William Hamilton found fossil shells in the Fosso Grande, and, in 1841, Monticelli enumerated 30 species.

The following List, re-arranged from that given by Roth in "Der Vesuv," is founded partly on the authority of Roth, and partly on that of Scacchi and Prof. G. O. Costa:—

PTEROPODA.

Hyalœa trispinosa, Lesueur.

GASTEROPODA.

Buccinum ascanias, Brug.
,, mutabile, Lin.
,, semistriatum, Broc.
Bulla hydatis, Lin.
,, lignaria, Lin.
,, truncatula, Brug.
,, utriculus, Broc.
Calyptræa vulgaris, Pil.
Cassidaria tyrrhena, Lam.
Cerithium mammilatum, Risso.
,, vulgatum, Brug.
Chemnitzia pallida, Phil.
Chenopus pes-pelicani, Phil.
Delphinula exilissima, Phil.
Dentalium dentalis, Lin.
,, entalis, Lin.
,, strangulatum, Desh.
,, spec.
Fusus rostratus, Olivi.
Limnæus ovatus, Drap.
Marginella secalina, Phil.
Natica intricata, Donov.
,, Guilleminii, Pasc.
,, macilenta, Phil.
Paludina tentaculata, Lin.
Pleurotoma costulatum, Risso.
,, nanum, Scacchi.
Ringicula auriculata, Mén.
Rissoa monodonta, Bivon.
,, oblonga, Desm.
Scalaria communis, Lam.
Siliquaria anguina, Lam.
Turritella communis, Risso.

LAMELLIBRANCHIATA.

Anomia spec.
Astarte incrassata, Jouk.
Cardium aculeatum, Lin.
,, ciliare, Lin.

Cardium Deshayesii, Payr.
„ echinatum, Lin.
„ edule, Lin.
„ rusticum, Chemn.
„ sulcatum, Lam.
„ tuberculatum, Lin.
Corbula nucleus, Lam.
Cytherea chione, Lin.
„ cyrilli, Scacchi (Venus minima, Mont.).
„ exoleta, Lin.
„ lupinus, Poli (C. lincta, Lam.)
„ rudis, Poli.
Donax semistriata, Poli.
„ trunculus, Lin.
Erycina angulosa, Bronn. (Tellina striata, Broc.)
„ Renierii, Bronn.
Isocardia cor, Lam.
Lima subauricula, Montagu.
Lucina commutale, Phil.
„ fragilis, Phil.
„ lactea, Lam.
Lutraria elliptica, Lam.
Mactra stultorum, Lin.
„ triangula, Ren.
Mesodesma donacilla, Desh. (Mactra cornea, Poli.).
Mytilus spec.
„ ?
Nucula margaritacea, Lam.
„ sulcata, Bronn.
Ostrea cristata, Born.
„ spec.
Pecten aspersus, Lam.
„ hyalinus, Phil.
„ jacobæus, Lin.
„ opercularis, Lam.
Pecten pygmœus, Münst.
„ sanguineus, Lin.
„ varius, Lam.
Pectunculus glycimeris, Lam.
„ pilosus, Lam.
Psammobia vespertina, Lam.
Saxicava arctica, Phil.
„ rugosa ? Lam.
Solen coarctatus, Lin.
„ ensis, Lin.
„ legumen, Lin.
„ siliqua, Lin.
Tellina donacina, Gru.
„ fabula, Gru.
„ nitida, Poli.
„ planata, Lin.
„ pulchella, Lam.
„ serrata, Broc.
„ tenuis, Met. and Rack.
Thracia phaseolina, Kien.
„ pubescens, Kien.
Venus fasciata, Dunov.
„ gallina, Lin.
„ ovata, Lin.

ANNELIDA.

Serpula cereolus, Gru.

FORAMINIFERA.

Polystomella crispa, d'Orb.
Quinquiloculina Akneriana, d'Orb.
„ longirostra, d'Orb.
Rosalina amaliæ, Costa.
„ radiata, Costa.
„ sub-radiata, Costa.
Triloculina cultrata, Costa.
„ flexa, Costa.
„ inflexa, Costa.

Those blocks containing well-preserved fossil shells have obviously been little acted upon by the volcanic fires, but many of the fragments, apart from the altered limestones, are by no means so unscathed, and consequently there is amongst them much

variety of lithological character, some being compact, some vesicular, and some conglomeratic or brecciated in structure or appearance.

The Ejected Blocks of Vesuvius have been obtained chiefly from the Rivo di Quaglia, Molara di Massa, Fosso Grande, and the Fosso di Cancheroni, and they occur abundantly as stated by Lavis in the beds exposed in the sections exposed in the Vallone Sanseverino, the Vallone di Pollena, and other places on the north-western slopes of Monte Somma.

CHAPTER X.

THE MINERALS OF VESUVIUS.

The Vesuvian Mountain the Richest Mineral Area—This Fact Important in Vulcanology—Introduction to Catalogue—Descriptive Catalogue of Vesuvian Minerals—Index of Synonyms and included Varieties.

THE extraordinary number of minerals which have been obtained from the Vesuvian area will, apart from its eruptive phenomena, ever render this district one of the greatest interest to the naturalist. Its richness as a field for the mineralogist is perhaps generally known, but to merely say that this area surpasses all others of equal size in the variety of its minerals, very inadequately states the fact. In the article "Mineralogy" in the new edition of the "Encyclopædia Britannica," 731 mineral species are enumerated, while occurring in the Vesuvian area alone, which is but a spot on the surface of the globe, upwards of a hundred distinct mineral substances are recognised by Prof. Scacchi. Nor is this fact of interest to the mineralogist only, since it is very suggestive, and bears significantly on the causes of volcanic action, for any hypothesis to account for such action should be capable of explaining how it is that so many more mineral species may be found in one volcanic area than in another. The physio chemical hypothesis—if the one I have

ventured to advance in this work may be so termed—appears to me to be the only one which offers a sufficient explanation of the remarkable and quite exceptional mineralogical richness of the Vesuvian volcano. Other theories require either a common source of lava, or extensive subterranean lava lakes or seas, and consequently such a conspicuous mineralogical pre-eminence of one small area as is found at Vesuvius would be in the highest degree improbable, if not altogether impossible.

It is most fortunate for science that at Naples, in the immediate neighbourhood of the volcano, there is so eminent a mineralogist as Prof. Archangelo Scacchi, who has been ever ready to examine the mineral productions of Vesuvius, and ever willing to describe them, and bring them before the notice of mineralogists and geologists all over the world.

Doubtless some of these minerals will be eventually determined to be rather varieties of others than worthy of distinct specific appellations; but, on the other hand, it is not too much to expect that future eruptions, and still further investigation, may give some additional species to the Vesuvian catalogue. The results of the critical examination of the products of the eruptions of recent years certainly point in this direction.

It has not been deemed requisite to burden the following descriptive notices of the minerals with crystallographic details that can only be stated in

an abstruse technical manner, and which possess an interest, or, indeed, a meaning, for only an extremely limited number of naturalists, and these few mineralogists have access to special mineralogical works, wherein such purely technical minutiæ may be found.

Prof. Scacchi's determination of species, as given in the recently published "Lo Spettatore del Vesuvio e dei Campi Flegrei," has been followed with but slight deviation, and the nomenclature has been based on that of the great American work, "A System of Mineralogy," by Prof. J. D. Dana, which favours the uniform termination *ite* to the scientific names of minerals.

The names here adopted, however, differ considerably from those of Prof. Scacchi, and also in several instances from those of Prof. Dana. The division of what has hitherto been regarded as a species into several having distinct names, and on the other hand, the grouping of named varieties having a similar chemical composition under one specific designation, occasion sometimes considerable difficulty in deciding upon the name possessing the greatest claim for adoption. But it is hoped that from the consideration which has been given to each, the names that have been decided upon may meet with general approval.

In the chemical formulæ the old system of symbolism has been employed from its being more generally familiar, as well as from its sim-

plicity and the distinctness wherewith it indicates the amount of oxygen in the oxygenated compounds, which form nearly the whole of the Vesuvian minerals.

For the convenience of visitors to the museums of Italy, and especially of those who may desire to examine the collections of Vesuvian minerals at Naples, the name used for each species by Prof. Scacchi is given in brackets following the name here adopted, and a list of synonyms and included varieties with references is appended.

Mineralogists are not yet in agreement on the best method of classifying minerals, and as any classification based on chemical composition is inconvenient to general readers, a simple alphabetical arrangement has been thought best adapted for this work. It will, with the Index of Synonyms, enable reference to the description of any species to be made without difficulty.

DESCRIPTIVE CATALOGUE OF VESUVIAN MINERALS.

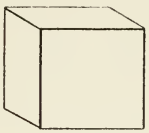
ALUM (Alume), Kalinite, Potash Alum, Native Alum, Common Alum.

Hydrous sulphate of alumina and potash, $KO\ SO_3 + Al_2O_3 3SO_3 + 24H_2O$, or sulphate of alumina 36.2, sulphate of potash 18.4, and water 45.5 = 100.

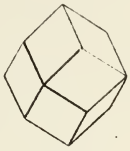
Alum crystallises in the Cubic System, in octahedrons, but it usually occurs fibrous or as a mealy

FIRST OR CUBIC SYSTEM

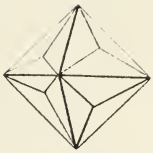
Octahedron



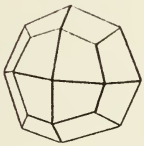
Cube



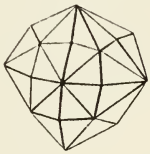
Rhombic Dodecahedron



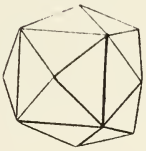
Three faced (Triakis) Octahedron



Trapezohedron



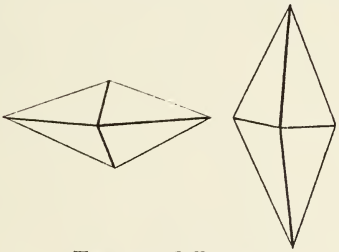
Six faced Octahedron



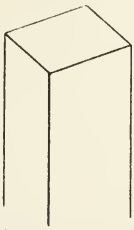
Four faced Cube

Pentagonal Dodecahedron

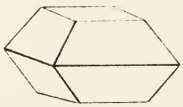
SECOND OR SQUARE PRISMATIC SYSTEM



Tetragonal Pyramids



Tetragonal Prism



Truncated Pyramids

LONDON: ROPER & DROWLEY, 11, LUDGATE HILL, E. C.

SIMPLE CRYSTALLINE FORMS

efflorescence. Hardness 2—2.5,* Specific Gravity 1.75. Its colour is white, with a vitreous lustre, and its crystals are transparent or translucent. It is very soluble in boiling water, little more than its own weight being sufficient for its solution, but it requires 16 to 20 times its weight of cold water. Before the blowpipe it quickly melts in its water of crystallisation, and then intumesces violently till it becomes a white spongy mass. Alum is well known by its sweetish astringent taste.

In Yorkshire, at Whitby, it is obtained from the "Alum Shales" of that place by lixiviation and evaporation, and in Dorsetshire it is manufactured from clay by the use of sulphuric acid. At Vesuvius it is not rare in the crater.

Amphibole, Haüy (Anfibolo), Hornblende, Tremolite.

The group of minerals to which the names Amphibole and Hornblende have been given contains varieties with a very considerable diversity of composition, but all agreeing in being silicates of magnesia and lime. Some, however, contain alumina, some have iron and some manganese, upon which differences a large number of names have been based. The composition of the Vesuvian

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* Scale of Hardness.

1. Talc.	6. Felspar.
2. Rock Salt.	7. Quartz.
3. Calcite.	8. Topaz.
4. Fluor.	9. Corundum.
5. Apatite.	10. Diamond.

mineral, as given by Prof. Scacchi, is simply silicate of magnesia and lime (MgO, CaO) SiO_2.

Crystallisation, Monoclinic; sometimes in isolated, sometimes in aggregated, and sometimes in macled crystals. It occurs also granular and fibrous as well as granular massive. Hardness 5—6, Specific Gravity 2.9—3.4. Colour usually a very dark green or black, but also lighter shades of green, and sometimes white. Opaque and translucent, usually subtranslucent, but occasionally transparent. Lustre, vitreous to pearly, and when fibrous, silky. When massive it is very tough, and has a subconchoidal fracture. The best-known varieties of Amphibole are Actinolite, Amianthus, Asbestos, Edenite, Grammatite, Hornblende, Rock Cork, Mountain Leather, Nephrite or Jade, Tremolite.

Amphibole, when the name is used comprehensively, is a very widely distributed mineral, occurring in a large number of igneous and crystalline rocks and in very many localities. At Vesuvius black amphibole is abundant in the crystalline masses of Monte Somma, usually associated with glassy felspar, and as white, yellow, or brown acicular and filamentose varieties, it occurs as a product of sublimation in the metamorphic conglomerate of the eruption of 1872.

Etymology: From ἀμφίβολος, ambiguous, from this mineral having been confounded with tourmaline.

Analcime (Analcime), Cubic Zeolite.

This is one of the class of minerals called Zeolites, from ζέω, to boil, all of them containing

water and intumescing before the blowpipe. Analcime is a silicate of alumina and soda with water, and is expressed by $3Al_2O_3Si_2O_3+6H_2O$=silica 54.6, alumina 23.2, soda 14.0, water 8.1=100.

It crystallises in the Cubic System in 24-sided trapezohedrons. Hardness 5—5.5, Specific Gravity 2.22—2.29. Colourless and white, but occasionally tinted variously. Lustre vitreous. Transparent to nearly opaque. Fracture subconchoidal. It is feebly electric by friction, and is readily decomposed by hydrochloric acid, when it yields viscid silica and so gelatinises.

Analcime occurs in the cavities of igneous rocks, and is found in those in the Orkneys and the Hebrides, at Dumbarton, at Arthur's Seat, and at the Giant's Causeway, as well as at many other localities in Scotland and Ireland. At Vesuvius it is found in the cavities of the ejected blocks of Monte Somma, but it is not common.

ANGLESITE (Anglesite), Anglesine.

Sulphate of lead, or $PbOSO_3$=oxide of lead 73.6, sulphuric acid 26.4=100.0.

Crystallises in the Rhombic System in rhombic prisms. Hardness 2.75—3, Specific Gravity 6.12—6.39. It is white, grey, or yellowish in colour, but frequently tinged blue or green by oxide of copper. Lustre adamantine inclining to resinous. Fracture conchoidal and very brittle.

Anglesite was so named from being first found in Anglesea. It occurs, however, in Derbyshire,

Cumberland, and in Scotland, both at Leadhills and Wanloch Head. At Vesuvius it was found on the lava of 1872 at Le Novelle.

ANHYDRITE (Anidrite).

Anhydrous sulphate of lime, CaO, So_3 = lime 41.18 and sulphuric acid 58.82 = 100.

Crystallisation Rhombic, usually in rectangular prisms, but it most commonly occurs in massive granular beds. The usual colour is white, but it is sometimes tinged bluish or reddish, with a lustre somewhat pearly. The hardness of Anhydrite is greater than that of the hydrous sulphate of lime, Gypsum, being 3—3.5, with a specific gravity of 2.899—2.985. It is sometimes transparent, but commonly translucent, and is doubly refractive. Does not effervesce with acids, but is slightly soluble in water.

In the British Islands Anhydrite occurs in Nottinghamshire and Derbyshire, and in Ireland at Cave Hill, near Belfast. At Vesuvius it occurs in the ejected lavas of Monte Somma and in the metamorphic conglomerates, but not common.

Etymology: *a*, without, and ὕδωρ, water.

ANORTHITE (Anortite), Christianite.

Silicate of alumina and lime, $3Al_2O_3 Si O_2 + Ca O Si O_2$ = silica 43.1, alumina 36.8, lime 20.1. An analysis by Abich of a specimen from Somma gave the following result: Silica 44.12, alumina 35.12, lime 19.02, peroxide of iron 0.70, magnesia 0.56, soda 0.27, potash 0.25 = 100.04.

Crystallisation Triclinic, Doubly Oblique, or, so called from this mineral, Anorthic. Hardness 6—7, Specific Gravity 2.66—2.78. Found in transparent to translucent white crystals having a vitreous lustre inclining to pearly, but in Glen Cairn and Labrador it is rose-red. It is brittle, and has a conchoidal fracture, and is entirely decomposed in hydrochloric acid.

Anorthite occurs in the Faroe Islands, in Iceland, the Ural Mountains, and other places. In Ireland it has been found in the Carlingford Mountain. At Vesuvius it is chiefly found in the cavities of compact calcite, associated with meionite, and occurs generally in the crystalline masses of Monte Somma.

Etymology: ἄνορθος, oblique, in allusion to its crystallisation.

Apatite (Apatite), Asparagus Stone, Moroxite, Phosphorite.

Phosphate of lime, $3Ca\,O\,PO_5 + Ca$ (Cl. F.) = lime 50., phosphoric acid 42.26, calcium 3.97, fluorine 3.77. Part of the fluorine is sometimes replaced by chlorine.

Crystallisation, Hexagonal; usually in six-sided prisms. Hardness 5, Specific Gravity 2.92—3.25. Colour usually white, but often variously coloured with pale tints as yellowish-white, sea-green, pale red, &c. Transparent to opaque with a vitreous lustre. Fracture conchoidal and uneven. Brittle. Some specimens are phosphorescent on incandescent charcoal. Apatite is associated with rocks con-

taining tin veins, but also occurs in limestone and serpentinous rocks.

In England this mineral is obtained from various localities in Cornwall, Devonshire, and Cumberland, and also in Scotland and Ireland. At Vesuvius it occurs, but not commonly, in the crystalline masses and metamorphic conglomerates of Monte Somma.

Etymology: ἀπάταω, to deceive, from its resemblance to other minerals.

Aphthitalite (Aftalosa), Glaserite, Arcanite, Vesuvian Salt.

A sulphate of potash, $KOSO_3$: potash 54.1, sulphuric acid 45.9=100, but it has always associated with it sulphate of soda and other salts. A specimen from Vesuvius contained sulphate of potash 71.4, sulphate of soda 18.6, chloride of sodium 4.6, chloride of ammonium, copper, and iron 5.4=100.0.

Crystallises in the Rhombic System. Hardness 3—3.5, Specific Gravity 1.731. Colourless or white, sometimes tinged with blue or green. Lustre vitreous. Transparent to opaque. Taste saline and bitter.

This salt occurs in thin tables, in crystalline blades, massive, and in crusts. At Vesuvius it is sublimed in delicate white crystallisations on the lava about the fumaroles and in the crater. It was found both on the lava of 1868 and on that of 1872. Aphthitalite occurs at other volcanoes also.

Etymology: ἄφθιτος, unalterable, and ἅλς, salt, this mineral being unalterable in the atmosphere.

ARAGONITE (Aragonite), Aragon Spath, Flos Ferri, Satin Spar.

Carbonate of lime, CaO, CO_2=lime 56.0, carbonic acid 44.00=100.

Crystallisation Rhombic, in radiating groups of acicular crystals, also columnar, fibrous, and silky. The calcareous incrustations in boilers are usually Aragonite. It is usually white, but sometimes tinted with yellow, blue, and green. Hardness 3.5—4, Specific Gravity 2.93. Fracture sub-conchoidal, with a vitreous lustre. Though the same in composition, Aragonite is harder than Calcite, which it scratches easily, and from which it may be otherwise distinguished by being heated, when it immediately becomes a powder, while calcite remains unchanged.

This form of carbonate of lime occurs both in North and South Devon, at Torbay and Ilfracombe, and in Cumberland, and fine crystals are found at Leadhills, in Scotland. At Vesuvius Aragonite is in the ejected lavas of Somma, and appears in radiated and minute crystals in cavities in the ejected calcareous blocks.

Etymology: From Aragon, in Spain, where it was first discovered.

ATACAMITE (Atacamite), Muriate of Copper.

Hydrochloride of Copper=Cu Cl + 3Cu O + 2HCO=oxide of copper 55.8, chloride of copper

31.5, water 12.7=100, or copper 59.45, chlorine 16.64, oxygen 11.25, water 12.66.

Crystallisation Rhombic, usually in small rectangular octahedrons of various shades of bright green. Translucent to sub-transparent. Hardness 3—3.5, Specific Gravity 3.9 to 4.3. Before the blowpipe Atacamite tinges the flame bright green or blue, and gives off fumes of hydrochloric acid. It is soluble without effervescence in nitric acid.

In England this mineral has been obtained at St. Just, in Cornwall, and in Australia at Burra Burra, but it occurs chiefly in South America, and from the Desert of Atacama, on the west of the Andes, it derives its name. At Vesuvius it is common in the chinks and crevices of the lava of the eruption of 1631, but Scacchi says the green substance in the crater is not Atacamite as is usually thought. (See Euchlorinite).

Atelite, A. Scacchi (Atelina).

Another hydrochloride of copper, which may perhaps be considered to be a variety only of Atacamite, having the composition, according to Prof. Scacchi, $Cu\,Cl + 2Cu\,O + 3H_2O$, and stated to be produced by the action of hydrochloric acid on the mineral Tenorite (which see).

Belonesite, A. Scacchi. (Belonesia.)

Molybdate of magnesia ?

This new Vesuvian species of Prof. Scacchi is rather rare, in minute acicular crystals in a fragment of ancient volcanic rock enclosed in

lava of the eruption of 1872. ("Lo Spettatore," p. 68.)

Biotite (Biotite), Mica in part, Magnesia Mica, Uniaxial Mica, Meroxene.

Silicate of alumina, magnesia, and potash, with iron $(Al_2O_3, Fe_2O_3)\ SiO_2 + (MgO, KO, FeO)^3\ SiO_2$. An analysis of Biotite from Vesuvius by Chodnef gave: Silica 40.91, alumina 17.79, magnesia 19.04, potash 9.96, protoxide of iron 7.03, peroxide of iron 3.00, lime 0.30=98.03.

Crystallisation, Hexagonal; in six-sided tabular prisms, with a perfect cleavage parallel to the base, but often in disseminated scales. Hardness 2.5—3, Specific Gravity 2.7—3.1. Colour usually dark brown or green, or black, but sometimes white or colourless. Biotite, like Muscovite, is highly sectile, and thin plates are both flexible and elastic. It is transparent to opaque, and optically uniaxial, thereby differing from common mica, or Muscovite, which is biaxial. Its lustre is pearly, inclining to metallic, and its streak uncoloured. Biotite may be readily distinguished from biaxial mica by its being entirely decomposed by strong sulphuric acid. It is but slightly acted upon by hydrochloric acid. Before the blowpipe it is only with difficulty fusible, when it produces a grey or black glass.

In Scotland Biotite occurs in Inverness-shire and Skye. At Vesuvius it is most abundant, while being variable in colour, in the crystalline masses of Somma. It is also to be found in the lavas of the

ejected conglomerates as well as, resulting from sublimation, in the chinks of the lava of 1631.

Etymology: Named after M. Biot, who first showed the optical peculiarities of the micas.

Blende (Blende), Sphalerite, Black Jack, Sulphide of Zinc, Zn S=zinc 67, sulphur 33=100.

Crystallisation Cubic in tetrahedrons; occurs also massive, fibrous, and botryoidal. Hardness 3.5—4.0, Specific Gravity 3.9—4.2. Colour brown, yellow, red, green, and black, whence the miner's name black-jack. Translucent, or opaque. Brittle with a conchoidal fracture, and Lustre resinous to adamantine. When strongly heated before the blowpipe it gives off vapours of zinc, and dissolves in nitric acid, giving off sulphuretted hydrogen.

Blende is common in metalliferous districts, and is associated with the ores of lead, silver, and copper. At Vesuvius it is rather rare in the crystalline calcareous masses of Monte Somma, where it is associated with galena.

Etymology: From the German *blendena*, brilliant (*blenden*, to dazzle).

Breislakite (Breislakite), Augite and Pyroxene in part.

This mineral, though having the same composition as Augite (which see), of which indeed it is but a variety, yet has a sufficiently distinct form to make it worthy, in Prof. Scacchi's opinion, of a separate place and designation. It occurs in fine brown flexible fibres or filaments, described as

"wool-like," not only at Vesuvius, but in the lava-rock of Capo di Bove, near Rome. At Vesuvius it is in the chinks of the older lava of the eruption of 1631.

CALCITE (Calce), Calcareous Spar, Iceland Spar, Double Refracting Spar.

Carbonate of lime, CaO, CO_2: lime 56, carbonic acid 44.

Crystallisation, Hexagonal; in an extraordinarily large number of forms, no less than 700 having been figured by Count Bournon, including 50 rhombohedrons and 155 scalenohedrons. The primary or fundamental form is an obtuse rhombohedron, which may be obtained by cleavage, and is well seen in Iceland spar, the purest form of calcite. Calcite also occurs massive (limestone), granular (marble), pisolitic (oolite), earthy (chalk), lamellar, fibrous, and stalactitic. Hardness 2.5—3.5, Specific gravity 2.508—2.778. When not colourless it is usually white, but it is often tinged with colour by various impurities such as iron, manganese, &c. Transparent, translucent, and opaque, with a vitreous or earthy lustre and white streak. A non-cleavage fracture is conchoidal. All forms of calcite may be readily known by their strong effervescence with acids. Before the blowpipe it is infusible, but when incandescent it gives an intense white light, while the carbonic acid is driven off leaving a residue of pure or quick lime. The transparent rhombohedral crystals of Iceland spar

possess very strong double refractive powers, giving to this form the name Double Refracting Spar. The following are other forms of Calcite: Dog-tooth spar, Nail-headed spar, Prunnerite, Natrocalcite, Reichite, Ferrocalcite, Neotype, Spartaite, Fontainebleau limestone, Hislopite, Satin spar, Aphrite, Lithographic stone, Stalactites, Oriental alabaster, Rock milk, Rock meal, Argentine.

Fine crystals of Calcite are obtained in Cumberland at Alston Moor and the Greenside mine, Derbyshire, Devonshire (Plymouth), Cornwall, and other localities. Andreasberg, in the Hartz Mountains, has long been famous for its six-sided prisms of Calcite, and in Iceland a crystal (rhombohedron) six yards long was found. At Vesuvius it is abundant in the crystalline masses of Monte Somma, and occurs enveloped in the lava of 1631. Sometimes it is found in the chinks of this lava crystallised in a form resembling balls of cotton-wool.

Etymology: From *calx*, Latin for lime.

Carbonic Acid Gas (Anidride Carbonica).

Anhydrous carbonic acid, CO_2.

This gas, Professor Scacchi says, is occasionally evolved at various points on the slope of the mountain, when it does great injury to the roots of trees that are planted in the neighbourhood.

Chessylite (Azzurrite), Azurite, Blue Copper, Blue Carbonate of Copper, Kupferlasur.

Hydrous carbonate of copper, or $2CuO, CO_2 +$

$CuO + H_2O$ = oxide of copper 69.2, carbonic acid 25.6, water 5.2 = 100.

Crystallisation, Monoclinic. Hardness 3.5—4, Specific Gravity 3.5—3.831. Colour, various shades of azure, passing into Berlin blue. Transparent to opaque. Brittle, with a conchoidal fracture. Before the blowpipe Chessylite decrepitates, and after turning black yields a globule of copper. It is soluble both in ammonia and nitric acid, and with the latter it effervesces.

At Chessy, near Lyons, from which place it derives its name, it is abundant and beautiful. It is a valuable ore of copper, but is not found in England in sufficient quantity to be so used. It occurs in Cornwall, Devonshire, Derbyshire, and Cumberland, as well as in Scotland and Ireland. At Vesuvius it is found on the sides of the chinks of the lava of 1631.

Chloralluminite, Scacchi (Coralluminio).

Chloride of aluminium, $Al_2 Cl_3$, Scacchi; $Al_2 Cl_6 + xH_2O$, Dana. (Att. Accad. Napole, VI.)

Produced along with Molysite and Chloromagnesite at the eruption of 1872.

Chlorocalcite, A. Scacchi (Clorocalcite).

Chloride of Calcium = $Ca Cl_2$, Dana; Ca Cl, Scacchi.

Crystallisation, Cubic; in small crystals with cubic, octahedral, and dodecahedral planes. Very soluble and deliquescing readily. It is mingled with chloride of soda, potash, and manganese, the per-

centage of $CaCl_2$ being 58.76. Produced by the eruption of 1872. Transparent, sometimes stained a light violet.

Chlorocalcite, crystallised, is abundant about the fumaroles of the craters.

Chloromagnesite, A. Scacchi (Cloromagnesite), Bischofite.

Chloride of magnesium, MgCl, or, according to Dana, $MgCl_2 + 6H_2O$ = magnesium 11.86, chlorine 35.04, water 53.10 = 100.

Hardness 1—2, Specific Gravity 1.65. Colourless to white, with a lustre vitreous to dull. It occurs mingled with the other chlorides of the crater of Vesuvius, and was obtained by crystallisation from a solution.

Chlorotionite, A. Scacchi (Clorotionite).

Chloride of potash and copper with sulphuric acid, $K,Cu,ClSO_4$, or $K_2SO_4 + CuCl_2$ = potassium 26.29, copper 19.56, chlorine 20.04, sulphuric acid 32.29.

Occurs in thin mammillary crusts of a bright blue colour, or, as stated by Scacchi, in the form of crystalline blue globules subsequent to the eruption of 1872. Dana considers this to be rather a mixture of two salts than a single species.

Etymology: Chlorine and θεῖον, sulphur.

Chondrotite, Bournon (Umite).

Silicate of magnesia, with part of the oxygen replaced by fluorine, same as Humite, but Monoclinic, and thus crystallographically as well as optically

distinct. This is Type II. of Humite as described by Prof. Scacchi, but determined by Des Cloiseaux to be crystallographically specifically separable.

Etymology: From χόνδρος, a grain, from its granular structure.

(See Humite and Clinohumite.)

Chrysolite (Peridoto), Smaragdus, Olivine, Peridote.

Anhydrous silicate of magnesia with protoxide of iron, $2(MgO, Fe O) Si O_2$. An analysis by Walmstedt of a Vesuvian specimen from Somma gave silica 40.08, magnesia 44.22, protoxide of iron 15.26, manganese 0.48, alumina 0.18 = 100.24.

Crystallisation Rhombic, usually in imbedded grains, and also compact or granular.

Hardness 6—7, Specific Gravity 3.33—3.50. Colour usually olive-green (Olivine), but sometimes greenish-yellow (Precious Chrysolite), and sometimes white (Forsterite). Transparent to translucent, with a vitreous lustre and conchoidal fracture. When powdered it is readily decomposed by hydrochloric and sulphuric acids, when with the separation of silica, it gelatinises. Before the blowpipe it is infusible when alone, but with borax fuses to a glass coloured by iron.

The darker-coloured mineral, Olivine, is largely disseminated in basalts and lavas, and occurs sometimes in grains and sometimes in masses, and it even constitutes rocks. Olivine is in the basalt of the

Giant's Causeway in Ireland, and in that of Arthur's Seat, Edinburgh, as well as in the modern lavas of Italy and the Sandwich Islands. At Vesuvius it is common in the crystalline masses of Somma, associated with biotite and augite, as well as in the lavas of both the ancient lavas of Monte Somma and the modern lavas of Vesuvius. On the sea-shore wave-worn rounded crystals of Olivine are often found.

The pale yellowish-green transparent variety, or Precious Chrysolite, has been used from ancient times as a gem, and was probably that which Pliny called "Topazion," while his "Chrysolite" was probably our Topaz. The white variety, Forsterite of Levy, which Dana describes as distinct from Chrysolite, occurs at Vesuvius in the calcareous masses with crystals of Pleonaste.

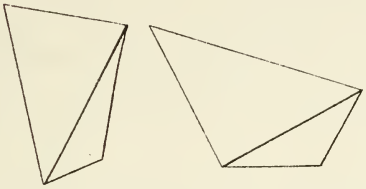
Etymology: Chrysolite, from χρυσὸς, gold, and λίθος, stone, or golden stone, from its colour. Olivine, named from its olive-green colour.

Clinohumite, Des Cloiseaux (Umite).

Silicate of magnesia, with part of the oxygen replaced by fluorine, same as Humite, but crystallographically and optically distinct.

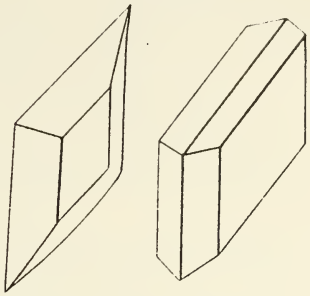
This is Type III. of Humite, as described by Prof. Scacchi, but which Des Cloiseaux ("Phil. Mag.," III., ii., p. 286. 1876) found to be Monoclinic, while Type I. is Rhombic, and thus to be sufficiently crystallographically distinctive to justify its being constituted a distinct species, and separable also by

THIRD OR RHOMBIC SYSTEM



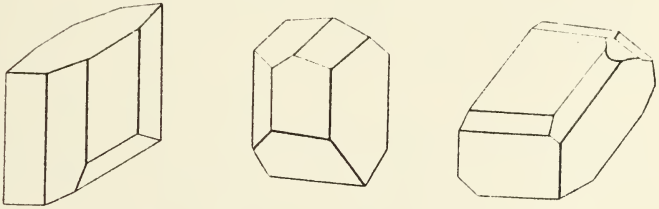
Combinations of Oblique Forms

FOURTH OR MONOCLINIC SYSTEM



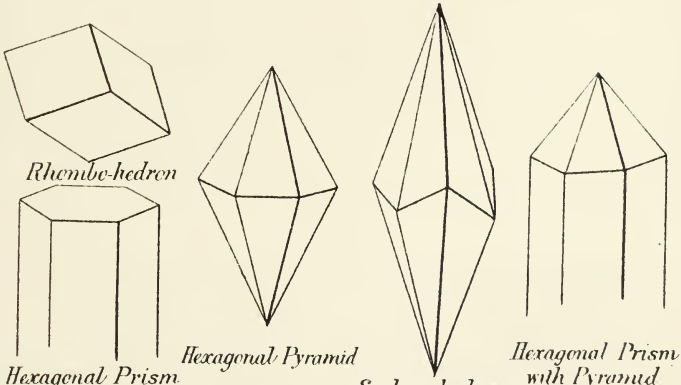
Tetragonal Sphenoids

FIFTH OR TRICLINIC SYSTEM



Combinations of Triclinic Forms

SIXTH OR HEXAGONAL SYSTEM



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SIMPLE CRYSTALLINE FORMS

its optical differences from Type II., which is also Monoclinic. (See Humite and Chondrotite.)

Coquimbite (Coquimbite), White Copperas.

Hydrous tersulphate of iron = $Fe_2O_3, 3SO_3 + 9H_2O$ = peroxide of iron 28.5, sulphuric acid 42.7, water 28.8.

Crystallises in the Hexagonal System, but occurs also in fine granular masses. Hardness 2—2.5, Specific Gravity 2—2.1. Colour white, yellowish, brownish, and sometimes with a pale violet tint. Fracture conchoidal, taste astringent. An analysis by Rose gave: Peroxide of iron 24.11, sulphuric acid 43.55, water 30.10, alumina 0.92, lime 0.73, magnesia 0.32, silica 0.31.

Occurs as a bed in a felspathic rock in Coquimbo, in Chili, and in Bolivia it forms part of a hill near Calama. It was obtained by Professor Scacchi at Vesuvius, from a solution of a brownish friable crust, about the fumaroles of the crater after the eruption of 1850.

Etymology: Called Coquimbite from Coquimbo, in Chili.

Cotunnite (Cotunnia).

Chloride of lead, Pb Cl = lead 74.5, chlorine 25.5 = 100.

Crystallisation, Rhombic; in small white acicular crystals. Hardness 2, Specific Gravity 5.238. Lustre adamantine, inclining to silky or pearly. Before the blowpipe this mineral fuses readily, emitting a white smoke and giving a blue colour to the flame. It

is also soluble in about twenty-seven times its weight of water.

Cotunnite was discovered by Monticelli and Covelli in the crater of Vesuvius after the eruption of 1822, along with chloride of sodium and chloride and sulphate of copper. It was also found after the eruption of 1839, and by Profs. Scacchi and Guiscardi on the lava of 1855, the unusual liquidity of which has been ascribed to this mineral. Scacchi says it is not rare in the craters and upon the lava (of 1872 ?).

Etymology: Named after Dr. Cotugno, of Naples.

Covellite, Beudant (Covellina), Covelline, Covellinite, Indigo Copper.

Sulphuret of copper, Cu S, Scacchi; $Cu_2 S_2$, Dana = copper 66.5, sulphur 3.35.

Crystallisation Hexagonal, but commonly massive or spheroidal. Hardness 1.5—2, Specific Gravity (of crystals) 4.590—4.636. Colour indigo blue, streak lead-grey to black. Lustre sub-metallic, inclining to resinous. Opaque; thin leaves flexible. It is soluble in nitric acid, and before the blowpipe burns with a blue flame, and with soda melts to a globule of metallic copper.

In England, Covellite occurs in Cornwall, at Huel Maudlin mine, and at several localities in Continental Europe. At Vesuvius it is in black or greenish-blue incrustations about the

fumaroles, sometimes in a net-work like a spider's web.

Etymology: Named after Covelli, the discoverer of the Vesuvian mineral.

CRYPTOHALITE, A. Scacchi (Criptoalite).

Fluo-silicate of ammonium = $NH_4 F + Si F_2$.

Found by Prof. Scacchi along with sal-ammoniac in the lava of 1872, and obtained from an artificial solution.

CUPRITE (Ziguelina), Zigueline, Red Copper Ore, Ruberite, Tile Ore.

Dioxide of copper, $Cu_2 O$ = copper 88.8, oxygen 11.2 = 100.

Crystallisation, Cubic; in octahedrons, dodecahedrons, and in cubes lengthened into capillary forms. It also forms granular, compact, and earthy masses. Hardness 3.5—4, Specific Gravity 5.6—6.15. Colour red of various shades, with an adamantine or sub-metallic to earthy lustre, and a brownish-red shining streak. The crystals are subtransparent to subtranslucent. It is brittle, with a conchoidal or uneven fracture. Cuprite is soluble with effervescence in nitric acid, and without effervescence in hydrochloric acid and ammonia. On charcoal before the blowpipe it is reduced and yields metallic copper.

This ore of copper is obtained in Cornwall, Devonshire, and Staffordshire, and at several localities on the Continent. At Vesuvius it is found in the chinks of the lava of 1631.

Cupromagnesite (Cupromagnesite).

A hydrosulphate of magnesia and copper, expressed by the formula, $Cu\ O\ Mg\ O, SO_3 + 7\ H_2\ O$.

This is one of the newly discovered species of Prof. Scacchi, obtained from the solution of some sublimations produced by the eruption of Vesuvius in 1872. These were in the form of bluish-green crusts of copper vitriol and sulphate of magnesia, and the crystals obtained from the solution were isomorphous with the sulphate of iron.

Cuspidine, A. Scacchi (Cuspidina).

Silicate of lime with fluorine = $Ca\ O\ Si\ O_2 + F$ and CO_2.

Orthorhombic, in spear-shaped crystals formed of two pyramids. Colour, pale rose-red.

Rare in the ejected blocks of Monte Somma.

Cyanochroite (Cianocroma), A. Scacchi's species but Dana's name.

Hydrous sulphate of potash and copper, $KO, SO_3 + CuOSO_3 + 6H_2O$, or, as Dana gives it, $\frac{1}{2}\ KOSO_3 + \frac{1}{2}\ Cu\ SO_3 + 3H_2O$.

Crystallisation Monoclinic, obtained from a solution of the saline crust of the crater of the eruption of 1855.

The colour is a clear blue, hence the name Cyanochroite, from κυάνος, blue, and χρόα, colour, given by Dana in preference to Scacchi's original word Cianocroma, a name suggesting the presence of chrome, which it does not contain.

Cyanosite (Cianosa), Cyanose, Calcantite, Chalcanthite, Blue Vitriol, Copper Vitriol.

Hydrous sulphate of copper, $CuOSO_3 + 5H_2O$ = oxide of copper 31.8, sulphuric acid 32.1, water 36.1.

Crystallisation Triclinic, but usually occurring stalactitic, reniform, and amorphous, or pulverulent. Hardness 2.5, Specific Gravity 2.213—2.27. Colour Berlin blue to sky blue. Transparent to translucent, with a conchoidal fracture, and vitreous lustre. Brittle. Taste metallic and nauseous. Soluble in three parts of cold water, but in boiling water a half-part is sufficient to effect a solution. This has a fine blue colour, and will deposit pure copper on iron with a bright surface. Cyanosite also yields metallic copper before the blowpipe on charcoal with soda.

This mineral occurs in many localities, especially in the waters of cupriferous mines. Scacchi says it is not rare near the fumaroles of the craters of Vesuvius, and produced by the emanation of $CuO\ SO_3$ being changed to Cyanosite by exposure to the ambient air.

Dolerophanite, A. Scacchi (Dolerofano).

Sulphate of copper = $Cu_2\ SO_3$ = copper 62.27, sulphuric acid 36.07, insoluble matter 1.22, loss 0.44 = 100. Another analysis: copper 65.20, sulphuric acid 33.49, insoluble and loss 1.31 = 100.

Crystallisation Monoclinic. The crystals are so minute that they seldom have a diameter of more

than two millimetres. Colour brown; opaque, but well polished. Powder brownish-yellow. Before the blowpipe fuses, leaving a black scoriaceous residue; but it is unaltered at a temperature of 260°.

This mineral was found by Prof. Scacchi beautifully crystallised, and not rare amongst the sublimations of the crater after the eruption of 1868. The crystals undergo decomposition, when the rocks on which they are deposited are disintegrated by the action of the atmosphere.

Etymology: From δολερός, fallacious, and φαίνω, to appear.

Dolomite (Dolomite), Dolomie, Bitterspar, Pearlspar, Rautenspath.

Carbonate of lime and carbonate of magnesia = $CaO\ CO_2 + MgO\ CO_2$ = carbonate of lime 54.35 and carbonate of magnesia 45.65 = 100. Carbonate of iron or carbonate of manganese are often present.

Crystallisation Rhombohedral. Often in granular masses as magnesian limestone. Hardness 3.5—4, Specific Gravity 2.8—3.1. Colour various, with a vitreous lustre, inclining to pearly. Subtransparent to translucent and brittle. It is soluble in acids, but not so readily as carbonate of lime. On the coast of Durham, where it constitutes the sea-cliff rocks near Sunderland, it assumes various curious forms, including globular and radiated concretions, and it also yields a fissile stone, thin slabs of which are quite flexible while not quite dry.

At Vesuvius it is not rare in the conglomerates of

Monte Somma, crystallised in small rhombohedrons with the faces parallel to the planes of exfoliation.

Etymology: Named after the eminent geologist Dolomieu.

Euchlorinite, A. Scacchi (Euclorina).

Sulphate of potash, soda, and copper = $(KO + NaO)\,SO_3 + 3CuO,\ 2SO_3$.

This mineral, in the form of a thin green crust, has been found at various times in the crater, and was mistaken for the chloride of copper or Atacamite. It was obtained abundantly amongst the sublimations of the crater, after the eruption of 1868.

Epsomite (Epsomite), Epsom Salts.

Hydrous sulphate of magnesia = $MgO,\ SO_3 + 7H_2O$ = magnesia 16.26, sulphuric acid 32.52, water 51.22 = 100.

Crystallises in the Rhombic System, and also occurs in botryoidal masses and delicately fibrous crusts. Hardness 2.25, Specific Gravity 1.751. Colour white, transparent to translucent, with a vitreous lustre, and bitter saline taste. Epsomite is soluble in less than double its weight of water, and before the blowpipe dissolves easily by its water of crystallisation, though it fuses with difficulty.

This salt occurs commonly in mineral waters, notably at Epsom, in Surrey, whence it takes its name, and is seen as an efflorescence on the surface of rocks. At the Mammoth Cave of Kentucky it forms loose snowball-like masses adhering to the roof. At Vesuvius it was obtained by crystallisa-

tion from solutions of the sublimations of the crater.

Eriochalcite, A. Scacchi (Eriocalco), Muriate of Copper.

Hydrochloride of copper.

This mineral was found by Professor Scacchi among the sublimations in the crater, after the eruption of 1868 (in 1869), like balls of cotton-wool, but of a bright blue colour. ("Bull. Soc. Min.," i., 132.)

Erythrosiderite, Scacchi (Eritrosidero).

Hydrous chloride of potash and iron.

Crystallisation Rhombic. Colour red, very soluble.

Found at Vesuvius after the great eruption of 1872 amongst the sublimations of the crater in very beautiful crystals. Erythrosiderite is related to Kremersite, which occurs in ruby red octahedrons.

Etymology: ἐρυθρός, red, and σίδηρος, iron.

Exanthalose, Beudant (Exantalosa).

Sulphate of soda with water = $Na\ O\ SO_3 + 2H_2O$, thus differing from Glauber salt or Mirabilite (which see) only in containing less water, that mineral having $10H_2O$ instead of $2H_2O$. The analysis of the Vesuvian mineral gave soda 35.0, sulphuric acid 44.8, and water 20.2.

This salt occurs as a white efflorescence, and may result from the exposure of Glauber salt to the air.

Considerable deposits of Exanthalose are found in Spain, and it is also found in veins in the salt

deposits of Villafranca, in the South of France. At Vesuvius it was obtained from the lava of 1813.

Etymology: ἐξανθέω, to effloresce, and ἅλος, salt.

Hæmatite (Ematite), Red Iron Ore, Iron Glance, Red Oxide of Iron.

Peroxide (sesquioxide) of iron = $Fe_2 O_3$ = iron 70, oxygen 30 = 100.

Crystallisation Hexagonal, but occurs columnar, granular, botryoidal, reniform, stalactitic, and lamellar. Hardness 5.5 — 6.5, Specific Gravity 4.5 — 5.3. In a tabular crystalline specimen from Vesuvius, Rammelsberg found protoxide of iron 3.11 and magnesia 0.74. This had a specific gravity of 5.303 and was magnetic. It also sometimes contains titanium. Colour dark steel-grey or iron-black when crystallised, but when earthy red, and in other forms reddish-brown. The streak is cherry-red or reddish-brown, distinguishing hæmatite from magnetite. Opaque except in very thin laminæ. Fracture sub-conchoidal and uneven, with a metallic lustre which is sometimes splendent.

Hæmatite is a most abundant and valuable ore of iron in England, on the Continent of Europe, and in the island of Elba. At Vesuvius it occurs abundantly amongst the sublimations of the fumaroles and the lavas.

Etymology: From αἷμα, blood. "'And the hæmatites, or blood-stone, which is of a dense, solid texture, dry, or, according to its name, seeming as if formed of concreted blood.'—Theophrastus, chap.

lxvi. Five varieties of hæmatite were known to the ancients, of which the most esteemed, and probably that referred to above, was obtained from Ethiopia." —*Bristow.*

Ferric Nitrate (Azoturo di Ferro).

Prof. Scacchi says that the very thin films of various colours with a metallic lustre which are on the surface of the scoria of the lava of 1884–5 have, according to Prof. Silvestri, the composition of nitrate of iron.

Fluorite (Fluorite), Fluor, Fluor Spar, Derbyshire Spar, Blue John.

Fluoride of calcium = Ca Fl = calcium 51.3, fluorine 48.7 = 100.

Crystallises in the Cubic or Monometric System, usually in large cubes and also in octahedrons and rhombic-dodecahedrons, and occurs, too, nodular compact, and earthy. Hardness 4, Specific Gravity 3.01—3.2. A mean of sixty specimens gave 3.183. Colour various, with a vitreous lustre and a white streak. Transparent to translucent. Fracture flat conchoidal. Fluorite exhibits a phosphorescent light when powdered and heated. Some crystals which appear blue by reflected light are green by transmitted light, a property termed "fluorescence" by Prof. Stokes.

This beautiful mineral is abundant in Derbyshire, where it is made into various ornamental articles. It also occurs in Cornwall, Devonshire, Cumberland, and Durham. At Vesuvius Fluorite in minute octa-

hedral crystals is found in the crystalline masses of Monte Somma, and has been obtained from the cavity of a lava probably of the eruption of 1631.

GALENITE (Galena).

Protosulphide or sulphuret of lead = PbS = lead 86.6, sulphur 13.4 = 100.

Crystallises in the Cubic System, usually in cubes, but often in octahedrons and other forms, with a perfect cleavage parallel with the planes of the cubes, and it also occurs in lamellar and granular masses. Hardness 2.5—2.75, Specific Gravity 7.25—7.70. Colour lead-grey, with a fine metallic lustre, which sometimes has an iridescent tarnish. Opaque. Sectile and easily pulverised. Galena contains silver in the proportion usually of 1 to 3 or 5 in 10,000, and rarely 1 per cent., and sometimes antimony, cadmium, copper, selenium, or zinc. Pure metallic lead may easily be obtained from the mineral before the blowpipe, when the sulphur is driven off.

In the British Islands the finest crystals have been obtained from the lead mines of the Isle of Man. It is the usual ore of lead, and extensively obtained both in that island and in Durham, Cumberland, and other counties of England, as well as in Scotland and Wales. At Vesuvius it is associated with blende in the calcite of the crystalline masses of Somma.

Etymology: From γαλήνη, tranquillity, from its supposed power to mitigate disease.

GARNET (Granato), Carbuncle of the ancients.

Silicate of alumina with a silicate of either lime, magnesia, or iron oxide, and sometimes with manganese or chromium oxide.

The composition of the Vesuvian mineral is given by Prof. Scacchi as $3(Ca\ Mg\ Fe)O$, $(Al\ Fe)_2\ O_3$, $3Si\ O_2$, which will place it as a lime-magnesia-iron garnet. An analysis, however, of a specimen from Vesuvius, by Wacht, gave the following result: Silica 39.93, alumina 13.45, lime 31.66, peroxide of iron 10.95, protoxide of iron 3.35, manganese 1.40 = 100.94, showing an absence of magnesia. To such a garnet Dana gives the name "Andradite." A simple lime garnet is grossularite, while the "common" and the precious garnet (Pyrope) are iron garnets, having the composition $Al_2\ O_3\ Si\ O_2 + 3FeO$ = silica 36.3, alumina 20.5, protoxide of iron 43.2 = 100. Several other names have been given to the different varieties.

Crystallises in the Cubic System, usually in dodecahedrons, also granular and lamellar. Hardness 6.5—7.5, Specific Gravity 3.1—4.3, specific gravity of iron garnet 3.7—4.21. Colour various, the most prized being a rich crimson. Transparent to opaque. Brittle with a sub-conchoidal, uneven fracture, but very tough when compact or cryptocrystalline. Most varieties are easily fusible before the blowpipe, the iron garnets giving an iron reaction.

The finest garnets are obtained from Pegu, and are called Syrian from the name of its

capital. Bohemia, Ceylon, and Brazil are other localities for precious garnets. In England garnets occur in Cornwall, Devonshire, and Cumberland. At Vesuvius Garnet is abundant and of various colours in the crystalline masses of Monte Somma, often associated with idocrase, and is likewise found, Scacchi says, as a rare product of the effect of sublimation in the conglomerate and in the bocche.

Etymology: From *garanatus*, from the mineral's red colour, resembling that of the seed of the pomegranate.

Graphite (Grafite), Tremenhurite (impure Indian variety), Plumbago, Blacklead.

Pure carbon, or C with a little iron oxide and earthy matter = carbon 98.8, ash 1.2.

Crystallises in the Hexagonal System in flat six-sided tables, but it is usually in concretionary or imbedded masses. Hardness 1 to 2, Specific Gravity 2.0891—2.229. Colour iron-black to a dark steel-grey, with a metallic lustre. It is opaque, sectile, has a greasy feel, and readily soils paper, whence its use for pencils. Graphite is infusible before the blowpipe, and is unaltered by acids, but at a high temperature burns without flame or smoke. It is used for crucibles intended to withstand great heat.

Masses of fine graphite of great value for the best artists' pencils are found at Borrowdale, in Cumberland, but the principal supply comes from abroad. It also occurs in Cornwall and the Isle of Man.

At Vesuvius it is in the crystalline calcareous masses of Monte Somna.

Etymology: From γράφω, to write, from being used for writing purposes.

Guarinita, G. Guiscardi (Guarinite).

Silicate of lime and titania = $(CaO + TiO_2)$ SiO_2 = silica 33.64, lime 28.01, titanic acid 33.92, with trace of peroxide of iron and peroxide of manganese.

Though similar to titanite or sphene in composition, Guarinite crystallises in the Square Prismatic System, while sphene is Monoclinic. Its colour is honey-yellow, with a sub-adamantine lustre. Translucent to transparent. Hardness 6—6.5, Specific Gravity 3.487.

Found at Vesuvius in minute crystals in small cavities in projected crystalline blocks of Monte Somma, consisting chiefly of glassy felspar, with hornblende and melanite. It was also found in the ordinary Somma lava-rock along with sphene.

Named after Prof. Guarini, of Naples.

Gypsum (Gesso), Selenite, Alabaster, Satin Spar.

Hydrated sulphate of lime = $CaO\ SO_3 + 2H_2O$ =lime 32.6, sulphuric acid 46.5, water 20.9 = 100.

Crystallises in the Monoclinic System, when it is called Selenite, but usually occurs in beds which are largely worked for the production of plaster of Paris, which is calcined Gypsum. Hardness 1.5—2 (may be easily scratched by the nail), Specific Gravity 2.2—2.4, colourless and white, sometimes coloured by

impurities. Crystals transparent or translucent. The value of gypsum for the making of a quick setting stucco or cement was known to the ancients, and Theophrastus mentions it under the name of γύψος, and describes the manner of preparing the cement, as well as the uses to which it was put in his time in Cyprus, Phœnicia, and Italy.

Gypsum is abundantly obtained in Staffordshire, Nottinghamshire, Derbyshire, and other counties, chiefly from Triassic rocks, and a very fine bed has been discovered in Purbeck strata, near Battle, in Sussex. At Vesuvius it is not uncommon amongst the sublimations of the crater.

Etymology: Ancient name γύψος, from γῆ, earth, and ἑψέω, to cook. Selenite, from σελήνη, the moon, from its fancied association with the moon.

Halite (Alite), Common Salt, Rock Salt.

Chloride of sodium, Na Cl = sodium 39.3, chlorine 60.7.

Crystallises in the Cubic System usually in cubes. Hardness 2, Specific Gravity 2.03—2.257. Colourless, but usually coloured with impurities. Transparent and translucent, with a vitreous lustre, and a conchoidal fracture. Its taste is typically saline.

It occurs in massive beds in England (Cheshire, Worcestershire, and Yorkshire), in the Trias, and also in Spain, Poland, the Tyrol, and other places in Europe. It is also found as a surface deposit covering large areas in Asia, America, and Africa, and as an efflorescence. At Vesuvius

it is abundant as a sublimation in the fumaroles of the crater and on the lava, but always containing a notable quantity of chloride of potassium.

HAUSMANNITE (Ausmannite), Raucierite.

Protoxide and peroxide of manganese, or $2MnO + MnO_2$ = protoxide of manganese 31.03, peroxide of manganese 69.07, or manganese 72.1, and oxygen, 27.9 = 100.

Crystallises in the Pyramidal or Dimetric System, in acute square-based pyramids, and it also occurs massive. Hardness 5.5, Specific Gravity 4.7 to 4.8. Colour iron-black, with a brown streak, and a metallic lustre. Very hard, with an uneven fracture. Dissolves in heated hydrochloric acid, giving off chlorine.

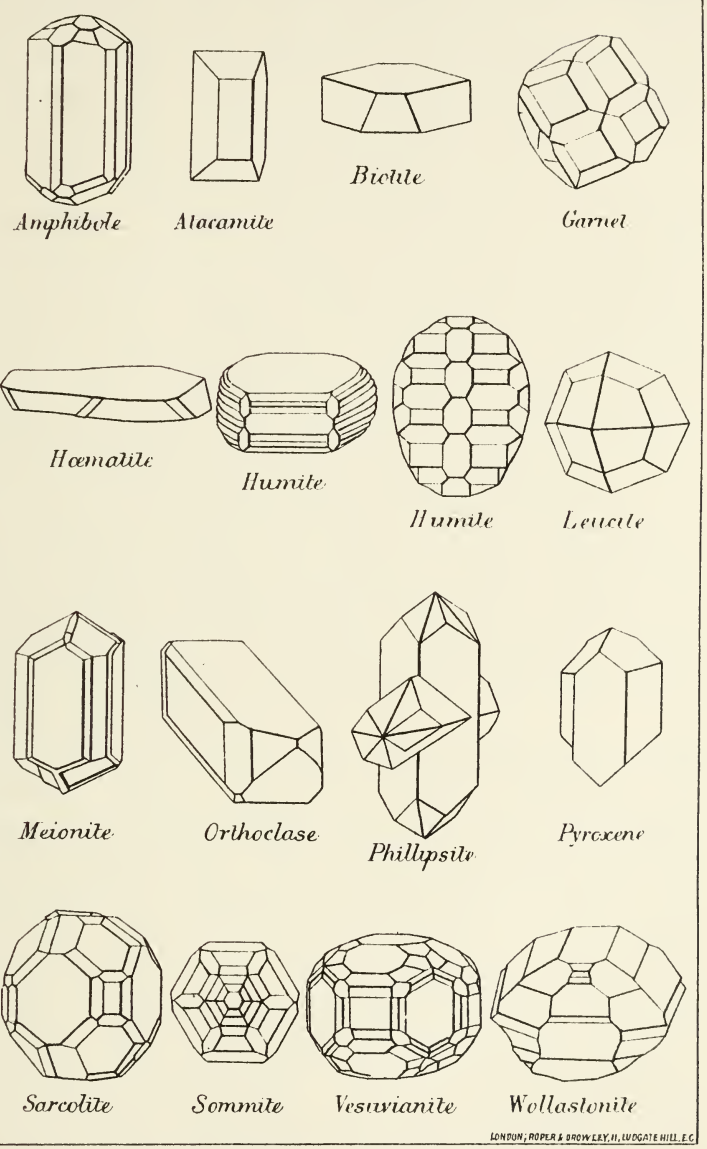
Hausmannite occurs in Thuringia, in the Hartz Mountains, and in Alsace. At Vesuvius it forms very thin crusts with rainbow reflections on the crystals of sodalite in the chinks of the lava of 1631.

Named after Professor Hausmann, of Göttingen.

HAÜYNITE (Auina), Haüyne, Haüyna, Latialite, Lazialite.

Silicate of alumina and soda with lime and sulphuric acid, or $3Al_2O_3\,SiO_2 + NaO_3\,SiO_2 + 2CaO + SO_3$ = silica 34.13, alumina 29.18, soda 14.69, lime 10.62, sulphuric acid 11.38 = 100.

Crystallises in the Cubic System in rhombic dodecahedrons and in octahedrons, and is also in grains and massive. Hardness 5.5, Specific Gravity 2.5. Colour indigo-blue, bright blue, asparagus-green.



CRYSTALS OF VESUVIAN MINERALS

Translucent and opaque, with a vitreous lustre. Very brittle, with a flat conchoidal fracture. Before the blowpipe haüynite decrepitates, and with borax effervesces, forming on cooling a yellow glass. Gelatinises in heated hydrochloric acid.

The occurrence of this mineral in the igneous rocks near Andernach, on the Rhine, is interesting as forming one of several points of resemblance between the volcanic products of the Eifel and those of the Italian volcanoes. Not only at Vesuvius, but at Monte Vulture and at Monte Albano also is Haüynite found. At Vesuvius it is tolerably common in the crystalline masses of Monte Somma.

Humite, Bournon (Umite), Chondrotite in part.

Silicate of magnesia, $8MgO\ 3SiO_2$, with part of the oxygen replaced by fluorine. An analysis by Rammelsberg of Vesuvian Humite gave: Silica 34.80, magnesia 60.08, fluorine 3.47, protoxide of iron 2.40 = 100.75.

Crystallisation, Rhombic; often hemihedral in octahedral planes producing forms monoclinic in character (Dana), Monoclinic (Brooke and Miller) (see Chondrotite and Clinohumite) in small implanted but distinct transparent to translucent crystals. Hardness 6—6.5, Specific Gravity 3.177—3.234. Colourless to yellow and brownish, usually yellow, with a polished glassy surface, giving a shining vitreous lustre. Dissolves in hydrochloric acid with the separation of gelatinous silica. It is also soluble in sulphuric acid, when the fluorine is

disengaged. Before the blowpipe the mineral is insoluble, but with borax fuses to a clear glass.

Humite occurs at Vesuvius in the ejected granular or crystalline masses of Somma, usually accompanied by spinelle.

The Vesuvian mineral was named Humite as a distinct species by Bournon, and although Rammelsberg showed it to be the same in composition as chondrodite of d'Ohsson, yet Des Cloiseaux found a sufficient crystallographic difference to constitute it a distinct species. Prof. Scacchi, in a very elaborate paper (Poggendorff's Annalen, 1851, Ergänzung, iii., 161), shows that there are three types of Humite, based on its crystalline forms and optical characters. These types are very fully and carefully described with complete mathematical details. Des Cloiseaux considers the three "types" of Scacchi to be optically distinct. Type I., Rhombic, he calls Humite; to Type II., Monoclinic, he allows the original name Chrondrodite, and to Type III., which appears to be Monoclinic also, he gives the name Clinohumite; and to this tripartite differentiation Prof. Scacchi, in "Lo Spettatore," gives his adhesion.

Etymology: The name was given in compliment to Sir Abraham Hume.

Hydrochloric Acid Gas (Acido Cloridrico).

Anhydrous hydrochloric acid, HCl.

This gas is an abundant emanation from the fumaroles of the crater.

Hydrocyanite, A. Scacchi (Idrociano).

Sulphate of copper, or $CuO\ SO_3$ = oxide of copper 49.47, sulphuric acid 50.30, loss 0.40 = 100.

Crystallisation Rhombic. Colour pale green, brownish or yellowish, and sky-blue, and the crystals are translucent. This mineral effloresces very readily by exposure to the atmosphere, from which it quickly absorbs water, forming cyanon or chalcanthite (which see).

Hydrocyanite was found by Prof. Scacchi at Vesuvius after the eruption of 1868, produced by sublimation, and it occurred in great quantities finely crystallised in 1870.

Etymology: ὕδωρ, water, and κυανος, azure blue. Dana says of the name, "an unfortunate name, suggesting a hydrous mineral, and one relating to *cyanite*."

Hydrodolomite, Rammelsberg (Idrodolomite).

Hydrous carbonate of lime and magnesia $(3Ca\ O + 3\ Mg\ O)\ 3CO_2 + H_2O$ or $Ca\ O\ CO_2 + Mg\ O\ CO_2 + \frac{1}{3} H_2O$. Results of two analyses of Vesuvian specimens:—

Lime.	Magnesia.	Carbonic Acid.	Water.
25.22	24.28	33.10	17.40 (Kobell).
26.90	23.23	43.40	6.47 (Rammelsberg).

Occurs massive and in stalactitic, stalagmitic, and globular concretions, as well as in crusts. Specific Gravity 2.495. Colour yellowish-white, greyish and greenish. Before the blowpipe yields water in a closed tube.

This mineral is abundant among the crystalline masses of Monte Somma. Prof. Scacchi says that

it is "probably derived from the fragments of magnesian limestone erupted from the ancient volcano, which have retaken from the ambient air the carbonic anhydrite lost through the high temperature to which they had been exposed."

HYDROFLUORITE, A. Scacchi (Idrofluore).

Hydrofluoric acid = HFl.

This compound in the gaseous form was first found emanating from the lava of 1850, but it has been observed at the fumaroles and on the lavas of 1870 and 1872.

HYDROMAGNESITE, V. Kobell (Idrogiobertite).

Hydrous carbonate of magnesia, or $3(Mg\,O\,CO_2 + H_2O) + Mg\,OH_2O$ = magnesia 43.9, carbonic acid 36.3, water 19.8 = 100.

Crystallisation Monoclinic. Occurs also amorphous and as chalky or mealy crusts. Hardness (of crystals) 3.5, Specific Gravity 2.145—2.18. Colour white, with a vitreous lustre passing to silky or sub-pearly, and earthy. Brittle.

Occurs in the Hebrides and in the Shetlands associated with Brucite. At Vesuvius it is rare, and found enclosed in a large fragment of ancient lava. Eugenio Scacchi gives it the name Idrogiobertite, and states the composition of the Vesuvian mineral as $Mg\,O,\,CO_2,\,3H_2O$.

Etymology: ὕδωρ, water, and magnesite.

LABRADORITE (Plagioclasia), Labrador Felspar, Lime Felspar.

Silicate of alumina, lime, and soda, $4Al_2\,O_3$

$SiO_2 + 3CaO\ SiO_2 + NaO$, $Si\ O_2$, or $(4Al_2\ O_3 + 3CaO + NaO)\ 8SiO_2$ = silica 52.9, alumina 30.3, lime 12.3, soda 4.5 = 100.

Crystallisation, Triclinic, often in twinned crystals; and also massive, granular, and sometimes cryptocrystalline. Hardness 6, Specific Gravity 2.67—2.76. It has various colours, as grey, brown, and green, and gives when polished very beautiful chatoyant reflections of various and brilliant tints, blues, greens, richbrowns, and lemon- gold- and orange-yellows. Brittle, with an imperfect conchoidal, uneven, or splintery fracture, and it has a vitreous lustre and a white streak. Unlike the potash felspar (orthoclase), this, the lime felspar, is entirely dissolved by heated hydrochloric acid when powdered, but before the blowpipe it is like orthoclase, difficultly fusible. From its beautiful play of colours Labradorite is manufactured into articles of jewellery.

This species of felspar was originally brought from the Isle of Paul, on the coast of Labrador, about 1770, and it occurs in many parts of North America. As a rock-forming mineral it is a constituent of the basic volcanic rocks, as basalt, dolerite, as well as of the plutonic rocks, diabase, hypersthenite, &c. At Vesuvius it occurs in glassy crystals in the crystalline ejected masses of Monte Somma.

In "Lo Spettatore," Professor Scacchi has adopted Breithaupt's name "Plagioclase," but as that designa-

tion embraces the whole group of triclinic felspars, viz., Labradorite, anorthite, andesine, oligoclase, and albite, and as the Vesuvian triclinic felspar appears to be Labradorite, that name is here used. It is, however, quite possible that further observation may reveal the presence at Vesuvius of the other triclinic felspars also.

Lapis Lazuli (Lapislazuli), Native Ultramarine, Sapphairos of the Ancients.

Silicate of alumina, soda, and lime, with a sulphide probably of iron and sodium = $(Al_2 O_3 NaO CaO) SiO_2$. An analysis by Varrentrapp gave: Silica 45.50, alumina 31.76, soda 9.09, lime 3.52, sulphuric acid 5.89, sulphur 0.95, iron 0.86, chlorine 0.42, water 0.12.

Crystallisation, Cubic in dodecahedrons; but it occurs usually massive and compact. Hardness 5.5, Specific Gravity 2.38—2.45. Colour rich Berlin or azure blue, with a faintly glimmering lustre. Opaque, but usually translucent at the edges. Fuses, only with intense heat, to a white enamel, but effervesces and forms a colourless glass with borax. Lapis Lazuli is the substance from which by pulverisation the highly valued pigment ultramarine is made, and the mineral in its native state is prized, on account of its beautiful colour, for mosaics and ornamental articles. The colour is probably due to the sulphide of sodium and iron.

Several parts of Asia, Persia, China, Bucharia, and near Lake Baikal, in Siberia, furnish the supplies of

the mineral. At Vesuvius it occurs in the compact limestone of the crystalline masses of Somma.

Leücite, Werner (Leucite), Amphigene, White Garnet.

Silicate of alumina and potash = $Al_2O_3\,3SiO$ + $KO\,SiO_2$, or as given by Scacchi, $KO, Al_2O_3\,4SiO_2$ = silica 55.0, alumina 23.5, potash 21.5 = 100. An analysis of a Vesuvian specimen by Rammelsberg gave: Silica 56.05, alumina 23.16, potash 20.04, soda 0.30, loss by ignition 0.52 = 100.07. Small quantities of lime and iron are also sometimes present.

Crystallisation, Cubic, usually in trapezohedrons; but frequently disseminated in lava-rocks in grains. Hardness 5.5—6, Specific Gravity 2.44 to 2.56. Colour cream-white, passing into ash-grey, rarely reddish-white, with a vitreous lustre. Translucent. Brittle, with an imperfect conchoidal fracture. Leucite is anhydrous analcime, from which it may be readily distinguished by its infusibility and by never having a cubical face.

Leucite is confined to volcanic rocks, and apparently to those of Italy and the Eifel in Germany. In the neighbourhood of Rome, at Borghetto Albano and Frascati, it is very abundant in prehistoric lava-rocks, giving to those rocks a value for millstones, which have been obtained from them for 2,000 years, since some have been found in Pompeii.

At Vesuvius, however, Leucite occurs in the finest crystals, and forms a most important mineral con-

stituent of the lavas of the volcano, both ancient and modern. According to Deville, the Leucite of the modern lavas of Vesuvius contains more soda than that of the ancient lavas of Somma, as shown by the following statement:—

Ratio of soda to potash in lava of	1855,	1 to 2.09
„ „	1847,	1 „ 1.67
„ „	Somma,	1 „ 8.21

Richter has found, by spectrum analysis, lithia in Vesuvian leucite. It is worthy of remark that potash, previously thought to be confined to the vegetable kingdom, was first found in minerals in Leucite by Klaprotte.

In the dykes of Somma the crystals of leucite are of the size of a pea, while the larger crystals of four centimetres diameter are in a particular kind of ejected lava, along with crystals of glassy felspar, and it is worthy of note that with the entire crystals are associated fragments of crystals indicating a second fusion, causing the fracture of many of the previously formed crystals. Amongst the conglomerates of Somma, crystals of augite carry on their surfaces minute crystals of leucite formed by sublimation. In the lavas of the eruption of 1631 there are considerable masses of crystals confusedly aggregated, and not so found on Somma. In the years 1844 and 1846 there were produced by Vesuvius crystals of leucite of the size of a pistol-shot.

Etymology: λευκός, white, from its prevailing colour.

LIMONITE, Beudant (Limonite).

Hydrated peroxide (sesquioxide) of iron, or $2Fe_2O_3 + 3H_2O$ = sesquioxide of iron 85.6, water 14.4.

Occurs commonly in mammillated, botryoidal, and stalactitic forms with a fibrous structure usually radiating. It is also compact, earthy, and disseminated. Hardness 5—5.5, Specific Gravity 3.6—4. Colour, various shades of brown with a silky lustre, but sometimes dull and earthy. It is soluble in warm nitro-hydrochloric acid; before the blowpipe blackens and becomes magnetic, but in thin fragments it fuses to a black magnetic glass.

Limonite is a very valuable ore of iron, and includes brown hæmatite, bog-iron-ore, wood hæmatite. It is likewise the oxide of iron that is disseminated in brown, yellow, and red clays and rocks, which from it derive their colour. At Vesuvius it is found in the crystalline masses of Monte Somma.

Etymology: From λειμών, a meadow, from its being produced in bogs or meadows as bog-iron-ore and meadow-iron-ore.

LINARITE (Linarite).

Cupreous sulphate of lead, $PbO, SO_3 + CuO, H_2O$ (Dana, Scacchi, and Bristow); $(PbO\ SO_3 + PbO, 2H_2O) + (CuO\ SO_3 + CuO, 2H_2O)$ (Heddle) = sulphate of lead 74.8, oxide of copper 19.7, water 5.5 = 100.

Crystallisation, Monoclinic, often in twinned

crystals. Hardness 2.5—3, Specific Gravity 5.3—5.5. Colour deep azure blue with a vitreous or adamantine lustre and conchoidal fracture. Translucent, and brittle with a pale blue streak. In the inner flame of the blowpipe Linarite gives a metallic globule which produces a coating of oxide of lead.

In England this mineral occurs in Cumberland, Red Gill and Roughton Gill, and in Scotland at Leadhills. At Vesuvius it was found among the sublimations of the crater of 1881, and described as one of them by Prof. Freada.

Etymology : The name is from Linares, a locality for this mineral in Spain.

Lithidionite, Eugenio Scacchi (Litidionite).

Silicate of potash and soda with copper and iron, or possibly (KO, NaO) $SiO_2 + CuO + FeO$ = silica 71.57, potash 10.92, soda 6.78, oxide of copper 6.49, protoxide of iron 4.02 = 99.78, but Dana regards it as a mixture of quartz with the other compounds it contains and not a definite species, and Prof. Archangelo Scacchi states that the composition does not correspond to any one simple formula.

Hardness 5—6, Specific Gravity 2.535. Colour blue.

Lithidionite was found at Vesuvius in the crater in June, 1873, coating lapilli of from 7 to 25 millemetres diameter, and consisting of a white earthy substance, with a glassy crust.

Magnesioferrite, Rammelsberg (Magnesioferrite), Magnoferrite.

Magnesian oxide of iron, $MgO\ Fe_2O_3$ = oxide of iron 80, magnesia 20 = 100.

Crystallisation, Cubic in octahedrons, some with truncated edges, but the crystals are usually intersected by very many extremely thin laminæ of hæmatite lying parallel to the faces of the octahedron. Hardness 6—6.5, Specific Gravity 4.568—4.838. Colour iron-black with a metallic or submetallic lustre and black streak, agreeing in all three with magnetite, and like it also strongly magnetic.

Magnesioferrite occurs at Vesuvius amongst the sublimations of the Fosso di Cancherone, and was also found produced from the lava of the eruption of 1855 at the foot of the great cone. Two of Rammelsberg's analyses of Vesuvian specimens—one of the mineral produced by the eruption of 1855, and one of that of an older eruption—gave results differing considerably. They are as follows:—

	Peroxide of Iron.	Magnesia.
Eruption of 1855	86.96	12.58 = 99.54.
Older . .	84.20	1.600 = 100.20.

Etymology: Rammelsberg originally named the species Magnoferrite, but Dana proposed Magnesioferrite, from magnesium and *ferrum*, iron, which is here adopted.

Magnetite, Haidinger (Magnetite), Magnetic Iron Ore, Lodestone.

Peroxide with protoxide of iron, or FeO, Fe_2O_3 = peroxide of iron 96.03, protoxide of iron 30.97 = 100, or iron 71.68, oxygen 28.32 = 100.

Crystallises in the Cubic System in regular octahedrons with an imperfectly lamellar structure, the laminæ being parallel to the planes of the octahedron. It also occurs earthy, compact, granular, and lamellar. Hardness 5.5—6.5, Specific Gravity 4.9—5.2. Magnetite has an iron-black colour, with a black streak and metallic or submetallic lustre. It is opaque and brittle, with an uneven or conchoidal fracture, and possesses the remarkable property of being strongly magnetic, which makes this mineral so famous as lodestone, and it moreover sometimes exhibits polarity. It is soluble in heated hydrochloric acid, but insoluble in nitric acid, and before the blowpipe becomes non-magnetic and turns brown, but is not easily fused.

Magnetite is a widely dispersed and abundant ore of iron, especially in the north of Europe, where in Sweden it constitutes the ore from which the fine Swedish iron is obtained, and several hills in the Scandinavian Peninsula, as well as in Lapland, are largely composed of it. In the British Islands it occurs in Cornwall and Devonshire, in Scotland, Shetland, and the Hebrides, and in several localities in Ireland. At Vesuvius it is to be found, but not abundantly, in the crystalline masses of Monte Somma.

Meionite, Haüy (Meionite).

Silicate of alumina and lime, $6CaO, 4Al_2O_3 9SiO_2$ (Scacchi), $3CaO\ SiO_2 + 2Al_2O_3\ SiO_2$ (Bristow) = silica 42.1, alumina 31.9, lime 26 = 100. An analysis

by Stromeyer of a specimen of Meionite from Monte Somma gave the following result: Silica 40.53 alumina 32.73, lime 24.24, soda and potash 1.81, protoxide of iron 0.18 = 99.50.

Crystallises in the Second or Square Prismatic System, usually in small four or eight sided prisms, terminated by four-sided pyramids, the angles of which are sometimes replaced. Hardness 5.5—6, Specific Gravity 2.5—2.74. (Crystal from Monte Somma, 2.734—2.737, Von Rath.) Colourless to white or greyish-white, with a vitreous lustre, and transparent to translucent, and often exhibiting many internal cracks. Meionite gelatinises in hydrochloric acid, in which it is quite decomposed, and before the blowpipe strongly intumesces and then fuses to a blistered colourless glass.

This mineral occurs at Vesuvius in the geodes or internal cavities of the granular compact limestone of the crystalline masses of Monte Somma. Scacchi says: "The inside walls of the cavities are covered with a green layer formed of biotite and pyroxene and with the meionite are often associated leucite and anorthite."

Etymology: From μείων, less, from the terminating pyramids of the crystals of meionite being less acute than those of Vesuvianite (Idocrase).

MELANOTHALLITE, A. Scacchi (Melanotallo).

Hydrochloride of copper.

Found in the form of black laminæ among the sublimations of the crater of Vesuvius in 1869,

associated with "Idrociano." On exposure to the air the black laminæ become green. Att. Accad. Napoli (Bull. Soc. Min., i., 38).

Melilite, Delamette (Melilite), Mellilite, Zurlite, Humboldtilite, Somervillite, Gelenite.

Silicate of lime and magnesia with a silicate of alumina and peroxide of iron, or $2(CaO, MgO)\ 2SiO_2 + (Al_2O_3, Fe_2O_3)\ SiO_2$ (Heddle), or $12(CaO_2\ MgO\ NaO) + 2(Al_2O_3\ Fe_2O_3)\ 9SiO_2$. An analysis by Damour of a specimen from Capo di Bove gave: Silica 38.34, lime 32.05, magnesia 6.71, soda 2.12, potash 1.51, alumina 8.61, peroxide of iron 10.02 = 99.36. One by Von Kobell of a specimen from Somma gave: Silica 43.96, lime 31.96, magnesia 6.10, soda 4.28, potash 0.38, alumina 11.20, protoxide of iron 2.32 = 100.20.

Crystallises in the Square Prismatic System in small square prisms, with the lateral edges usually replaced. Hardness 5—5.5, Specific Gravity 2.910—3.104. Colour shades of yellow from yellowish-white to yellowish-brown. Translucent to opaque, with a vitreous or resinous lustre, but transparent when in thin laminæ, and possesses weak double refraction. Fracture uneven to conchoidal. This mineral is soluble in nitric acid, and before the blowpipe is reduced to ashes without flame and almost without emitting an odour.

Occurs in the pre-historic lava of Capo di Bove in association with nephiline and pleonaste.

The Vesuvian varieties of Melilite, the Humboldt-

ilite of Monticelli and Covelli, the Somervillite of Brooke, and the Zurlite of Ramondini, occur in the crystalline blocks of Monte Somma. Melilite has also been found in a Somma lava, and Zurlite is often associated with green crystalline pyroxene. Humboldtilite is found in cavities associated with greenish mica and covered with a calcareous coating.

The gelenite stated by Monticelli to be a Vesuvian mineral is also, on the authority of Prof. Scacchi, a variety of Melilite.

Etymology: μέλε, honey, from its colour.

Microsommite, A. Scacchi (Microsommite).

Silicate of alumina, lime, potash, and soda, with chlorine and sulphuric acid, or (Al_2O_3, CaO, KO, NaO) $SiO_2 + Cl + SO_3$ = silica 33.0, alumina 29.0, lime 11.2, potash 11.5, soda 8.7, chlorine 9.1, sulphuric acid 1.7 = 104.2. This species differs in composition from sommite or nepheline in containing chlorine and sulphuric acid.

Crystallises in the Hexagonal System in very small hexagonal crystals, frequently in groups, with vertical striations and sometimes truncated edges. Hardness 6, Specific Gravity 2.60. Colourless to yellow, and transparent with a silky lustre.

This Vesuvian species occurs as a result of sublimation in the cavities of the ejecta of the eruption of 1872.

Etymology: μικρος, small, and sommite.

Millerite, Haidinger (Millerite), Capillary Pyrites.

Sulphuret or sulphide of nickel, or NiS = nickel 64.9, sulphur 35.1 = 100.

Crystallises in the Hexagonal System in capillary six-sided prisms; and, rarely, in columnar tufted coatings partly semi-globular and radiated. Hardness 3—3.5, Specific Gravity 4.6—5.65. Colour brass-yellow, inclining to bronze-yellow, with an iridescent tarnish. Opaque with a metallic lustre and bright streak. Brittle. Dissolves easily in nitro-hydrochloric acid, forming a green solution, but in nitric acid alone it is only with difficulty soluble. Before the blowpipe it discharges its sulphur in sulphurous acid, and after fusion leaves a magnetic bead of nickel.

Millerite is found in South Wales in cavities in nodules of clay ironstone, and it occurs in the mines of Devon and Cornwall. The largest crystals, but only a fifth of a line in diameter, have been obtained from Sterling Mine, New York. At Vesuvius Millerite was found by Prof. Freda among the sublimations of the crater.

Named after Prof. Miller, of Cambridge.

Mirabilite, Haidinger (Exantalosa), Glauber Salts.

Hydrous sulphate of soda, $NaO\,SO_3 + 10H_2O$ = soda 19.3, sulphuric acid 24.8, water 55.9 = 100.

Crystallisation, Monoclinic; usually occurring as an efflorescence or earthy. Hardness 1.5—2, Specific Gravity 1.48. Colour greyish or yellowish white with a dull surface lustre, but fresh fractures

vitreous. Transparent to opaque, very efflorescent, and falls to powder readily. The taste is cooling, then feebly saline and bitter. It is very soluble in water, and in the closed tube before the blowpipe yields much water in which it dissolves.

Mirabilite is in the hot springs of Bohemia, and is found in large quantities in Spain. At Vesuvius it was obtained from a solution of the salts collected in the crater.

Etymology: The name Glauber Salts is from the name of the discoverer of the artificial salt, Glauber, a German chemist, who exclaimed, "Sal mirabile!" hence "Mirabilite." Though Prof. Scacchi calls this salt in "Lo Spettatore" "Exantalosa," he shows its difference from Beudant's species, which has ten parts of water.

Mizzonite, A. Scacchi (Mizzonite).

Silicate of alumina, lime, and soda, $6(CaO, NaO)\ 4Al_2O_3\ 15SiO_2$ (Heddle), similar in composition to that of Meionite. The similarity and difference will be seen from the following two analyses of Vesuvian specimens:—

	Silica.	Alumina.	Lime.	Soda and Potash.		
Mizzonite	54.70	23.80	8.77	9.83	2.14	ign. 0.13 = 99.59 —V. Rath.
Meionite	40.53	32.73	24.25	1.81	P.O. of Iron	0.18 = 99.50 —Stromeyer.

Crystallises in the Square Prismatic System in larger prisms than Meionite. The general characters are like those of Meionite, but is not so readily acted upon by acids, and does not intumesce so much before the blowpipe. It is a Vesuvian

mineral exclusively so far as is yet known, and occurs in the crystalline ejected blocks of Monte Somma like Meionite, but differs from it in being associated with glassy felspar instead of with calcite.

Etymology: μείζων, greater, from the axis of the prism being larger than in Meionite.

Molybdenite (Molibdenite), Molybdena, Molybdic Acid.

Bisulphide of molybdenum, MoS_2 = molybdenum 59.0, sulphur 41.0.

The System in which this mineral crystallises is somewhat doubtful, but the balance of authority appears to be that it is the Hexagonal. Dana, however, gives "Monoclinic?" also. It is found in short or flat hexagonal tables, but it usually occurs massive, with a foliated structure, or in scales. Hardness 1—1.5, easily indented with the finger nail. Specific Gravity 4.44—4.80. It has a lead-grey colour, both colour and lustre resembling those of freshly-cut lead. The laminæ are very flexible, but like lead not elastic. It is opaque, and leaves a metallic grey mark on paper, and a greenish one on porcelain, and has a greasy or unctuous feel. In boiling sulphuric acid Molybdenite dissolves, forming a blue solution after giving off sulphurous acid, which it also does before the blowpipe, and on platinum wire colours the outer flame green. It is distinguished from Plumbago by its lustre and streak.

This mineral in the British Islands occurs in

granular limestone, and in granite in several parts of Scotland—Ross, Aberdeen, Argyll, Perthshire, and Kirkcudbrightshire—and in England in Cornwall, Cumberland, and Westmoreland. It is often associated with Apatite and Tungstate of Lime. In the last-named county, at Shap, it is used in the preparation of blue carmine for colouring porcelain. At Vesuvius it is rather rare in the crystalline ejected blocks of Monte Somma.

Molysite (Molisite).

Chloride of iron, $Fe_2 Cl_3$ = iron 34.5, chlorine 65.5 = 100.

Molysite occurs as an incrustation on the lavas of recent eruptions of Vesuvius, and was noticed by Hausmann in 1819, and by Prof. Scacchi as a result of the eruptive activity of the volcano between the years 1850 and 1855. Its general colour is a yellowish darkening into a brownish red, and to this mineral is to be attributed the yellow colour of the lavas about the fumaroles and craters. Prof. Scacchi has not found the protochloride of iron, Fe Cl, on Vesuvius as announced by Monticelli and Covelli, who probably mistook Molysite for that compound.

Etymology : μόλυσις, stain, from the stain it gives to lavas.

Monticellite, Brooke (Monticellite).

Silicate of lime and magnesia ($2Ca O + {}_2MgO$) $Si O_2$ Scacchi, or $(\frac{1}{2}Ca O + \frac{1}{2} MgO)^2 Si O_2$ = silica 38.5, lime 35.9, magnesia 25.6 = 100.

Crystallisation Right Prismatic and isomorphous

with Chrysolite. Occurs in small imbedded crystals and also massive. Hardness 5—5.5, Specific Gravity 3.03—3.25. Colourless to yellowish-grey. Nearly transparent to translucent, having the general aspect of quartz, and like that mineral having a vitreous lustre and a conchoidal fracture. It is soluble in dilute Hydrochloric Acid, and forms a clear solution, which, on heating, gelatinises.

Monticellite is found at Vesuvius imbedded in the crystalline calcareous ejected blocks of Monte Somma, with black Mica and small crystals of Augite.

Named after Monticelli, the eminent Neapolitan mineralogist.

Neochrysolite (Neocrisolito).

Anhydrous silicate of lime and protoxide of iron, $2(CaO, FeO)\ Si\ O_2$. The composition of this mineral differs from that of Chrysolite (Olivine or Peridote) in containing lime instead of magnesia.

Crystallises in the Rhombic System in small black crystalline plates.

Neochrysolite occurs at Vesuvius in the Cupa di Sabataniello, not uncommonly in the cavities of the lava of the eruption of 1631, as an effect of sublimation.

Neocyanite, A. Scacchi (Neociano).

Anhydrous silicate of copper (probably).

Crystals, Monoclinic, extremely small and tabular, of a beautiful blue colour.

This mineral has not yet been fully examined.

It was found about the fumaroles and amongst the sublimations of the Vesuvian crater of October, 1880, associated with three other substances. One, probably Silica, was a white granular mass, having a Specific Gravity of 2.287. The second was a white substance like Asbestos, but containing lime, only decomposible in boiling acid, and fusible with difficulty. The third, insoluble in acid, was in yellowish-brown crystals in six-sided rhombic plates.

Orpiment (Orpimento), Auripigmentum of Pliny.

Sulphuret of Arsenic, As_2S_3 = arsenic 61, sulphur 39.

Crystallisation, Rhombic in small crystals, but much more commonly massive, foliated, or columnar, as well as reniform and disseminated. Colour, shades of a yellow commonly called lemon-yellow, but darkening into a golden yellow. Hardness 1.5—2, Specific Gravity 3.4—3.48. Subtransparent or translucant only at the edges, with a resinous lustre and a streak paler than the colour. It is sectile, and thin laminæ are flexible, but not elastic. It dissolves in nitro-hydrochloric acid, and in caustic alkalies, and before the blowpipe burns with a bluish flame, emitting sulphurous and arsenical fumes.

Orpiment occurs in Persia in splendid yellow masses, called golden orpiment, and the mineral is obtained also from several parts of Central Europe. At Vesuvius it is rare among the sublimations of the crater. It was first found by Bergman, and after-

wards by Monticelli subsequent to the eruption of 1822. It occurs also at the Solfatara.

Etymology: The name is from Auripigmentum, or gold paint, from its use as a pigment, and the belief that it contained gold.

Orthoclase (Ortoclasia), Orthoclase Felspar, Potash Felspar, Common Felspar.

Silicate of Alumina and Potash, $Al_2 O_3\ 3Si\ O_2 + KO\ Si\ O_2$ = silica 64.8, alumina 18.4, potash 16.8 = 100. An analysis by Abich of Orthoclase from Baveno gave: Silica 65.72, alumina 18.57, potash 14.02, soda 1.25, lime 0.34, magnesia 0.10 = 100.

Crystallisation, Monoclinic, in oblique rhombic prisms often twinned. Orthoclase, which is one of the three constituents of ordinary granite, occurs also massive, granular, compact, sometimes lamellar, and sometimes flint- or jasper-like. Colour, white, grey, flesh-coloured, rose-red, and sometimes green, with a vitreous lustre and a greyish-white streak. Transparent, translucent, and opaque. Fracture conchoidal to uneven. Hardness 6, Specific Gravity 2.44—2.62. Orthoclase is not affected by acids, and before the blowpipe only fuses with difficulty to a turbid glass, but is very liable to decomposition by the carbonic acid of the atmosphere which, combining with some of the potash, and the remainder combining with part of the silica forming two soluble compounds, leaves an insoluble silicate of alumina as a clay (kaolin),

and thus granitic rocks become disintegrated and destroyed.

Orthoclase is a most abundant mineral, being a constituent of granitic and syenitic rocks and ordinary porphyries, as well as of the acidic or trachytic volcanic rocks. Fine crystals are displayed in the granites of Shap, Westmoreland, and in some of those of Cornwall. The Cornish crystals are well shown in the stonework of London Bridge. At Vesuvius, glassy Orthoclase is abundant in the crystalline masses of Monte Somma, and occurs in the ejected lavas of Somma too, derived, Prof. Scacchi thinks, from a metamorphism of crystals of leucite. It is also found in small lamellar crystals in the chinks of the lava of 1631.

Etymology: From ὀρθὸς, straight, and κλάω, to cleave. Varieties of Orthoclase: Adularia, Moonstone, Necronite, Amazonstone, Sanidin, Microlin, Loxoclase, Perthite, Murchisonite, Hälleflinta.

Periclasite, Scacchi (Periclasia).

Magnesia with Protoxide of Iron, $MgO + FeO =$ magnesia 89.04, protoxide of iron 8.56 (Scacchi); magnesia 93.38, protoxide of iron 6.01 (Damour).

Crystallisation, Cubic, in octahedrons with a perfect cubic cleavage in small clustered crystals, and in grains. Hardness 6, Specific Gravity 3.674—3.75. Colour greyish to dark green, with a vitreous lustre. Transparent to translucent. It is only with difficulty soluble in nitric acid, and is infusible before the blowpipe.

Periclasite occurs at Vesuvius, disseminated through the "lamellose calcite" of the crystalline ejected masses of Monte Somma, and is sometimes associated with Forsterite and earthy magnesite.

Etymology: From περί, around, and κλάσις, cleavage, from its cleavage at the angles.

Phillipsite, Levy (Fillipsite), a Zeolite.

Hydrous Silicate of Alumina, Potash, and Lime $=Al_2O_3\ 3SiO_2+(KO + CaO)\ SiO_2 + 5H_2O=$ silica 47.9, alumina 20.5, lime 7.4, potash 6.3, water 17.9=100.

Crystallisation, Rhombic, occurring in twin or complex cruciform crystals. Hardness 4—4.5, Specific Gravity 2.21. Colour white, but sometimes pink, with a vitreous lustre, and uneven conchoidal fracture. Translucent to opaque. Easily and entirely decomposed in hydrochloric acid with gelatinisation, and as a zeolite gives off water before the blowpipe. In the British Islands it is found chiefly in the igneous rocks of the North of Ireland, where it occurs in white or flesh-coloured translucent crystals. In Italy it occurs in the old lava rock of Capo di Bove, near Rome, and at Vesuvius it is abundant in the ejected lavas of Monte Somma, where it has been mistaken for Gismondine of Beaudant, or Abrazite of Breislak.

Etymology: It is named after the English mineralogist, William Phillips.

Picromerite, A. Scacchi (Picromeride).

Hydrous Sulphate of Potash and Magnesia, KO

$SO_3 + Mg\,O\,SO_3 + 6HO$ = potash 23.5, magnesia 9.9, water 26.8 = 100.

Crystallisation, Monoclinic, in crystals and crystalline crusts. Hardness 2.5. Colour white.

This mineral was obtained from the sublimations of the crater of 1857 by solution, and it has also been found at the salt mine of Stassfurt.

Etymology: From πικρος, bitter, in allusion to the magnesia present.

PROIDONITE, A. Scacchi (Proidonina).

Fluoride of Silicon, $Si\,Fl_2$.

An emanation of the lavas of Vesuvius during the eruption of the year 1872, and Prof. Scacchi thinks probably produced by other eruptions among the exhalations of the crater and lavas (Att. Accad. Napoli, vi., 1873).

PSEUDOCOTUNNITE, A. Scacchi (Pseudocotunnia).

Chloride of Lead with Chloride of Potassium, $PbCl + KCl$ or $PbCl_2 + KCl$.

This mineral, which has the composition of a combination of Cotunnite and Sylvine, was obtained from the sublimations of the crater of Vesuvius following the great eruption of 1872, and occurred in the form of acicular yellow crystals that were both opaque and without lustre. Cotunnite itself was associated with the Pseudocotunnite.

PYRITE (Pirite), Pyrites, Marcasite, Iron Pyrites, Mundic, Pierre d'Arquebuse.

Bisulphide of Iron, FeS_2 = iron 46.7, sulphur 53.3 = 100.

Crystallisation, Cubic, in cubes and pentagonal dodecahedrons, sometimes single and isolated, sometimes in groups, but the mineral commonly occurs in nodules in chalk, clays, and other rocks, spheroidal, reniform, botryoidal, and in other forms with a radiated subfibrous structure and crystalline surface. It also occurs as an impregnation and incrustation of organic remains, and sometimes it is massive and amorphous in immense quantities as at Rio Tinto, Spain. The paler variety, called Marcasite, crystallises in the Rhombic System, usually in brilliant crystals, some very pale, almost tin-white, called Pierre des Incas, from being used by the Incas of Peru for amulets. The colour is a pale brass yellow, with a splendent to glistening metallic lustre, and a greenish or brownish black streak. Hardness 6—6.5, Specific Gravity 4.83—5.03, Polished crystals 5.2. Sufficiently hard to strike fire with steel. Brittle with a conchoidal, uneven fracture, and when fractured a smell of sulphur is perceived. Though scarcely acted on by hydrochloric, it dissolves in concentrated nitric acid, but leaves a residuum of sulphur. Before the blowpipe it burns with a blue flame, and in the outer or reducing flame it easily passes to a black globule, which is magnetic. This mineral, not used as an ore of iron, is largely employed for the manufacture of copperas and sulphuric acid.

Pyrite is very largely and widely distributed, being found in many rocks and in many countries.

In England it occurs abundantly in nodules in the Chalk of the south-eastern counties and in the London Clay, especially of the Isle of Sheppey, as well as in other clays, especially the Gault and the Kimmeridge Clay, the fossils of which are often encrusted with the mineral. It also occurs in isolated crystals in the slates and other rocks of Wales, Scotland, and Ireland. The great deposit at the Rio Tinto mines, near Huelva, in Spain, consists of a cupiferous Pyrite, the mineral containing from 1 to 10 per cent. of copper, for which metal the mines are worked. At Vesuvius it is not common, but occurs in the ejected lavas of Monte Somma.

Etymology: The original name πυρίτης, full of fire, was used by Pliny, the mineral giving forth sparks or fire when struck with steel, but the name now adopted (Pyrite) is from πῦρ, fire, and the usual mineralogical termination *ite*. Pierre d'Arquebuse is from the mineral having been used instead of flint in early times for firearms.

Pyroxene, Haüy (Pirossene), Augite, Volcanite.

Pyroxene, like Amphibole, is the name for a large number of sub-species of minerals all agreeing in being Silicates of Lime and Magnesia with Iron, or (CaO, MgO) SiO_2+FeO. It thus has three of the essential constituents of Amphibole, but in Pyroxene the amount of Lime is greater than that of the Magnesia, while in Amphibole the reverse is the case. Like Amphibole, pyroxenous

minerals may be divided into two groups, one containing little or no Alumina, and the other being decidedly aluminous. The Vesuvian Pyroxene is an aluminous mineral, as shown by the following analysis by Kudermatsch : Silica 50.90, lime 22.96 magnesia 14.43, protoxide of iron 6.25, and alumina 5.37=99.91.

Crystallisation, Monoclinic, usually in short thick crystals, often twinned. It also occurs amorphous, roughly lamellar, granular and fibrous, the fibres being sometimes long and fine. Hardness 5—6, Specific Gravity 3.23—3.5. The colour, similar to that of Amphibole also, is usually very dark, either a dark green or black, but sometimes it passes through shades of green to white. It is opaque to transparent, with a vitreous lustre, in some cases pearly, a white or grey streak, and a conchoidal uneven fracture. Brittle. Pyroxene is only slightly acted upon by acids, but fuses with effervescence before the blowpipe and yields a light or dark coloured glass.

The dark or black Pyroxene, more properly that called Augite, is one of the chief constituents of the basic volcanic rocks or lavas, and hence the term Augitic as applied to such rocks.

Pyroxene is a widely distributed mineral occurring in igneous rocks in many localities. At Vesuvius it is abundant in the crystalline blocks and the metamorphic conglomerates of Somma, and from its variable character it has been mistakenly

named Topaz, Epidote, and Tourmaline. Small crystals of Augite are common in the crater and are often the product of eruptions.

Etymology : From πῦρ, fire, and ξένος, a guest, from its igneous origin. Varieties of Pyroxene : Malacolite, Mussite, Sahlite, Diallage, Fassaite, Schiller Spar, Epidote, Uralite, Jeffersonite.

Pyrrhotite, Brithaupt (Pirrotina), Pyrrhotine, Magnetic Pyrites.

Sulphide of Iron, $Fe_7 S_8$ = iron 60.5, sulphur 39.5 = 100.

Crystallisation, Hexagonal, in irregular six-sided prisms, with a perfect cleavage parallel to the base. It is, however, rare in crystals, and usually occurs massive and amorphous. Hardness 3.5 — 4.5, Specific Gravity 4.4—4.7. The colour is darker than that of Pyrite, being between bronze-yellow and copper colour, and its surface speedily tarnishes on exposure to the air. It has a metallic lustre and greyish-black streak, is brittle, with an imperfect conchoidal fracture, and is to some extent magnetic. Pyrrhotite is soluble in hydrochloric acid, giving off sulphuretted hydrogen, and fuses before the blowpipe into a greyish-black globule, also magnetic. It is distinguished from Pyrite both by its colour and its much less hardness.

This mineral occurs in mining localities in England, Wales, Scotland, and Ireland; and at Vesuvius it is found, but not common, in the crystalline masses of Monte Somma.

Etymology: From πυρροτής, reddish, from its colour.

Quartz (Quarzo), Rock Crystal.

Pure Silica, or Silicic Acid, $Si O_2$=silicon 46.67, oxygen 53.33.

Crystallisation, Hexagonal, in six-sided prisms terminated by six-sided pyramids. Also massive, granular to cryptocrystalline, or flint-like. Frequently in veins (vein quartz), often containing particles of gold. Hardness 7, Specific Gravity 2.5—2.8. Colourless (Rock Crystal, "Pebbles"), white (Milky Quartz), grey to black (Smoky Quartz), golden yellow (Cairngorm), violet (Amethyst), and rose coloured (Rose Quartz), &c. It has a vitreous lustre and a good conchoidal fracture. Transparent to opaque. Quartz is insoluble in every acid except hydrofluoric, and is infusible before the blowpipe when alone, but with soda fuses with efflorescence to a glass.

Varieties of Quartz: Agate, Chalcedony, Flint, Chert, Opal, Jasper, Carnelian, Cat's Eye, Onyx, Sard, Sardonyx, Chrysoprase, Heliotrope, Lydian Stone, Siliceous Sinter, Wood Opal, Silicified Wood, &c.

Quartz often contains small cavities filled or partly filled with a liquid of unknown composition, but called by Dana Brewsterlinite, which expands 25 per cent. with an increase of 30° Fahr., being twenty-one times more expansible than water. On exposure to the air, dries to separate particles, which,

however, even by the moisture of the hand, become again liquid, when the fluid resumes its rapid movements.

The finest crystals of pure colourless transparent Quartz (Rock Crystal) are found in the Alps of Switzerland and Savoy, the neighbourhood of Andermatt on the St. Gothard being a well-known locality. In the British Islands, Cornwall, Devon, Derbyshire, Cumberland, and North Lancashire furnish good crystals. At Clifton, in Gloucestershire, the crystals are known as "Bristol diamonds," and from Wales, Scotland, and many localities in Ireland, Rock Crystal is obtained. As a rock-forming mineral, Quartz forms enormous masses of sands and sandstones, quartzites and conglomerates, as well as the sands of the sea-shore. At Vesuvius it is in the ejected lavas of Monte Somma and in the fragments enveloped in the lava of 1631.

Realgar (Risagallo), Red Arsenic, Red Sulphuret of Arsenic.

Sulphide or Sulphuret of Arsenic, $As\,S =$ arsenic 70.07, sulphur 29.93.

Crystallisation, Monoclinic, in prismatic crystals, and also granular and compact. Hardness 1.5—2, Specific Gravity 3.4—3.6. Colour, orange-red of various shades, with a resinous lustre and a yellow streak. It is sectile and may be scratched with the finger-nail. Its fracture is conchoidal to uneven, and it becomes negatively electrical by friction.

Realgar is soluble in caustic alkalies, while before the blowpipe it fuses readily in the closed tube, and exposed to the air burns with a blue flame, giving off sulphurous and arsenical fumes.

Realgar is obtained from several localities in Central Europe, and at Vesuvius it was found by Monticelli and Covelli in the crater after the great eruption of 1822.

Etymology: The name used by the alchemists.

Sal Ammoniac (Clorammonio), Muriate of Ammonia, Salmiac.

Chloride of Ammonium, NH_4Cl = ammonium 33.7, chlorine 66.3 = 100. A Vesuvian specimen gave Klaproth: Chloride of ammonium 99.5, sulphate of ammonia 0.5.

Crystallisation, Cubic, in small octahedrons, but generally stalactitic, or in crusts, or as an efflorescence. Hardness 1.5—2, Specific Gravity 1.528. Colour white, but sometimes tinged greyish or yellowish by impurities. It is transparent to opaque, with a dull external and vitreous internal lustre, a conchoidal fracture, and a saline pungent taste. It is soluble in water, but only sparingly so in alcohol, and sublimes before the blowpipe at a great heat, but does not fuse.

In England, Sal Ammoniac is found near ignited beds of coal, but it is most common as a sublimation near volcanoes. At Vesuvius it is abundantly crystallised upon crusts of lava some time after consolidation, and is stated to be found in the crater.

There is a beautiful yellow variety coloured by chloride of iron.

Etymology: Ammonia from *hama nijak* (Arabic), dung of camels which was burnt to produce the salt.

SARCOLITE, Thomson (Sarcolite).

Silicate of Alumina and Lime with Soda, $3Al_2O_3$, Ca O, $3Si O_2 + Na O$, or according to Dana, $(\frac{1}{2}(\frac{9}{10}$ Ca $O + \frac{1}{10}$ Na $O)^3 + \frac{1}{2}Al_2O_3)^2$ $3Si O_2$ = silica 39.7, alumina 22.8, lime 33.4, soda 4.1 = 100. An analysis of a specimen from Somma by Prof. Scacchi gave: Silica 42.11, alumina 24.50, lime 32.43, soda 2.93 = 101.97. Prof. Dana says that Sarcolite has a nearly corresponding composition to that of Idocrase or Vesuvianite (which see), but it appears to me to be considerably different.

Crystallisation, Square Prismatic, in small flesh-coloured or brownish-white crystals, semi-transparent, with a vitreous lustre. It is very brittle, and generally so filled with incipient cracks that the mineral easily falls to pieces. Sarcolite gelatinises with acids and fuses to a white enamel.

At Vesuvius it is found in the crystalline ejected blocks of Monte Somma associated with Wollastonite and Hornblende, but its occurrence is rare.

Etymology: From σάρξ, flesh, and λίθος, stone, from its prevailing colour.

SASSOLITE (Sassolino), Boric Acid, Boracic Acid, Native Sedative Salt.

Hydrated Boracic Acid, $BO_3 + 3H_2O$ = boracic acid 56.4, water 43.6 = 100.

Crystallisation, Triclinic, usually in small scales, probably six-sided tables, and sometimes it occurs in stalactitic forms which are also made up of small scales. Hardness 1, Specific Gravity 1.48. The true colour is white, but it is sometimes yellowish from the presence of sulphur. Transparent to translucent, with a pearly lustre and a smooth and unctuous feel. Taste acid, but slightly bitter and saline. Sassolite is both very easily soluble and easily fusible. It is soluble in water and alcohol, the flame of which it colours green, and it fuses in the flame of a candle, to which it also gives a green colour until the water of crystallisation is driven off.

The mineral is especially abundant in the crater of Vulcano in the Lipari Islands. The Tuscan lagoons, where it was first found by Hoefer, yield 7,000 to 8,000 pounds troy a day. At Vesuvius it was discovered by Monticelli and Covelli in the crater in 1817.

Etymology: Named from Sasso, near Sienna, where it was first discovered.

Scacchite, Adam (Scacchite).

Chloride of Manganese, Mn Cl.

After the eruption of 1855 the saline incrustations on the lava were dissolved in distilled water, and the solution was tested with ferrocyanide of potassium, with the result that a white precipitate was formed which in a little time acquired a roseate tint, and thus the existence of the Chloride of Manganese was ascertained. In "Lo Spettatore" Prof. Scacchi

says it is common among the deliquescent salts of the crater.

Scolecite, Fuchs (Scolezite), Skolezit.

Hydrous Silicate of Alumina and Lime (Al_2O_3 CaO) $3SiO_2+3H_2O$=silica 45.8, alumina 26.2, lime 14.3, water 13.7=100.

Crystallisation, Monoclinic, in prismatic and acicular crystals, often twinned; but it occurs massive and also in nodules, with a fibrous and radiating structure. Hardness 5—5.5, Specific Gravity 2.2—2.7. Colourless and white, and also of pale grey, yellow, and red tints, with a vitreous lustre, or silky when fibrous. It is translucent towards the edges, is brittle, having an uneven fracture, and is pyro-electric. Scolecite gelatinises with hydrochloric acid, and with oxalic acid dissolves with separation of Oxalate of Lime. Before the blowpipe its action is peculiar, twisting and curling like a worm previous to fusion, when it forms a blistered glass.

This mineral was obtained from the igneous rocks of Staffa and other islands in the Hebrides as well as from Iceland, the Faröes, and other localities. At Vesuvius certain globules with a radiate structure in the ejected lavas of Somma are considered by Prof. Scacchi to be Scolecite.

Etymology: σκώληξ, a worm, from its action before the blowpipe.

Sodalite (Sodalite).

Silicate of Alumina and Soda with Chloride of

Sodium, $3Al_2O_3\ SiO_2 + NaO^3SiO_2 + NaCl$, or $3[(Al_2O_3)^2\ (SiO_2)^3] + 3NaO\ 3SiO_2 + 2NaCl$= silica 37.1, alumina 31.7, soda 19.2, sodium 4.7, chlorine 7.3=100.

Crystallisation, Cubic, in rhombic dodecahedrons; and massive. Hardness 5.5—6, Specific Gravity 2.136—2.37. Colour various, as white, grey, yellowish, greenish, lavender, blue, and light red, with a vitreous lustre. It is translucent, and has a conchoidal fracture. With hydrochloric acid, Sodalite yields gelatinous Silica, and before the blowpipe it fuses, and forms, like Scolecite, a blistered glass, sometimes intumescing.

This mineral is found in many northern localities in both Europe and America, and at Vesuvius it is in large white dodecahedral crystals, occurring in the crystalline masses of Monte Somma, the chinks of the lava of 1631, and in the metamorphic conglomerates ejected by the eruption of 1872.

Etymology : From soda and λίθος, a stone.

Sommite, Delametherie (Sommite), Nepheline, Nephelite, Davyne, Cavolinite, Elæolite, Beaudantite.

Silicate of Alumina, Soda, and Potash, $5Al_2O_3\ SiO_2 + 4NaO\ SiO_2 + KO\ SiO_2^2$ (Scheerer), or $Al_2O_3\ SiO_2^3 + (NaO^3, KO^3)\ SiO_2^3 + 3SiO_2$= silica 44.2, alumina 33.7, soda 16.9, potash, 5.2= 100. Three analyses of Vesuvian specimens gave :—

By	Silica.	Alumina.	Soda.	Potash.	Lime.	Peroxide of Iron.	Water.
Arfved ...	44.11	33.73	20.46	—	—	—	0.62= 98.92
Scheerer...	44.03	33.28	15.44	4.94	1.77	0.65	0.21=100.32
Scheerer...	44.29	33.04	14.93	4.72	1.82	0.39	0.21= 99.40

Crystallisation, Hexagonal, in six-sided (the primary form) and twelve-sided prisms, with the summits either plane or having the edges replaced, some terminated by the faces of many pyramids. The faces of the pyramidal terminations are some (Nepheline) at 135° 10′, and some (Davyne) at an angle of 154° 9′ to the plane of the base. It occurs also compact and columnar. Hardness 5.5—6, Specific Gravity 2.5—2.65. Colourless and greyish and yellowish white, but when massive it is of various tints, as green, bluish and reddish, with a vitreous, or a shining or silky lustre, and varies from transparent to opaque. The variety Davyne has a feeble lustre, and Rammelsberg states contains Carbonate of Lime, while Cavolinite is marked by a silky lustre. It is brittle with a subconchoidal fracture, and possesses, though weakly, double refraction. Sommite gelatinises with acids, and before the blowpipe fuses to a colourless blistered glass.

This mineral is in both Plutonic and Volcanic rocks, and has been found at Capo di Bove, and in several localities in Central Europe. The variety Elæolite occurs in Northern Europe and Asia, and in North America. At Vesuvius, Sommite was first found in crystals in the ejected crystalline blocks of

Monte Somma, some associated with glassy felspar, and some associated with Pyroxene and Biotite.

Etymology: Although this mineral is usually called Nephelite by mineralogists, who have generally adopted Haüy's name of 1801, I prefer the name Sommite, as used by Professor Scacchi, both from its indicating the original locality and from priority, it having been given by Delametherie to the species in 1797. Nepheline is from νεφελή, a cloud, from strong acids producing cloudiness. Elæolite, from ἔλαίον, oil, from its greasy lustre.

Spinelle (Spinello), Pleonaste, Rubicelle, Almandine.

Anhydrous Aluminate of Magnesia, but usually with Silica and Oxide of Iron, when pure Mg O $Al_2 O_3$ = alumina 71.99 and magnesia 28.01 = 100. Two analyses of Vesuvian specimens by Abich gave :—

Alumina.	Magnesia.	Silica.	Iron Protoxide.	Iron Peroxide.
67.46	25.94	2.38	5.06	... = 100.85
62.84	24.87	1.83	3.87	6.5 = 99.56

Part of the magnesia is sometimes replaced by lime and the protoxides of zinc and manganese.

Crystallisation, Cubic, in octahedrons and rhombic dodecahedrons and sometimes in macles. Hardness 8, Specific Gravity 3.5—4.9. The colour varies much, and determines the names of the varieties, the fine red Spinelle being the Spinelle Ruby, and the rose-red the Balas Ruby of jewellery, while the orange-red is Rubicelle, and the violet

Almandine. The dark-coloured or black is named Pleonaste, which is the usual Vesuvian variety; Almandine, the other Spinelle of this area, occurring very rarely. Spinelle is transparent to almost opaque, with a vitreous lustre or white streak, and a flat-conchoidal fracture. It is soluble only with difficulty in hydrochloric and strong sulphuric acids, and is infusible before the blowpipe, but red Spinelle when cooling becomes green, and then nearly colourless, but subsequently again becomes red as at first. Spinelle is distinguished from Oriental Ruby by being only 8 instead of 9 in the Scale of Hardness, by having less specific gravity, and by its crystallisation.

In the British Islands, Spinelle occurs in small rounded grains in the beds of the mountain streams of Wicklow, but the Spinelle Rubies are chiefly from Burma, Ceylon, and Cashmere. At Vesuvius the mineral is found in the crystalline ejected blocks of Monte Somma, and usually associated with Peridote and Humite.

Sulphate of Manganese (Solfato Manganoso).

Found by Monticelli and Covelli in the "red sand" of the 24th October, 1872, which was one of the products of the great eruption of that year.

Sulphatite, Dana (Solfatite), Oil of Vitriol.

Hydrous Sulphuric Acid, $SO_3 + H_2O =$ sulphuric acid 81.6, water 18.4 = 100.

Liquid, Specific Gravity 1.85, colourless. Dilute sulphuric acid is found occasionally near volcanoes.

In cavernous hollows in an old volcano in Tuscany, near Sienna, and in a cavern at Aix-les-Bains, as well as in several American localities, it is also present. Its formation is due to the oxidation of sulphuretted hydrogen.

Sulphuretted Hydrogen Gas (Idrogeno Solforato).

Sulphur and Hydrogen, HS.

This gas is evolved from the fumaroles of the crater, but does not appear to be abundant or indeed common.

Sulphurous Acid Gas (Anidride Solforosa).

Anhydrous Sulphurous Acid, SO_2.

Prof. Scacchi reports this gas as being a common emanation from the fumaroles of the craters.

Tenorite, Semmola (Tenorite), Melaconite.

Protoxide of Copper, Cu O = copper 79.85, oxygen 20.15.

Crystallisation, Hexagonal, in laminæ sometimes triangular, and it also occurs earthy and pulverulent. It is doubtful whether the same species is not trimorphous, if not quadrimorphous, since a similar oxide of copper, melaconite, is Cubic, some crystals of which from Cornwall have been found to be Monoclinic, while Kalkowsky says Tenorite is Triclinic. Hardness 3, Specific Gravity 5.952—6.25. Colour, dark iron-grey to black, opaque with a metallic lustre, or dull and earthy, and black streak. Folia elastic. It is soluble in hydrochloric and nitric acids, and before the blowpipe on charcoal

fuses and gives a red globule which in nitric acid dissolves with effervescence. Tenorite was found by Prof. Maskelyne to possess double refraction.

This mineral occurs at Vesuvius as a sublimation often with chloride of sodium on the lavas and about the bocche and fumaroles of the crater.

Etymology: Tenorite is so named in compliment to Signor Tenore, President of the Neapolitan Academy of Sciences.

THENARDITE, Casaseca (Pirotecnite).

Anhydrous Sulphate of Soda, $Na\ O\ SO_3$ = soda 56.18, sulphuric acid 43.82 = 100.

Crystallisation, Rhombic, in rhombic octahedrons giving acute pyramids, aggregated in crusts and in drusic cavities. Hardness 2—3, Specific Gravity 2.55—2.73. Colour white to brown, translucent, with a vitreous lustre; possesses double refraction; has a saline taste, and effloresces with a white powder on the surface on exposure to the atmosphere. It is quite soluble in water, and the crystals of the Vesuvian mineral were obtained from a solution of the sublimations of the crater.

Thenardite is deposited from the waters of a spring at Les Salines d'Espartines, near Aranjuez, in Spain, and it occurs at Tarapaca, in Peru. At Vesuvius it was on the scoriæ of the eruption of 1855.

The name is in compliment to Thenard, the French chemist.

THOMSONITE, Brooke (Comptonite).

Silicate of Alumina, Lime, and Soda with water (one of the Zeolites) = (Ca Na) O, $Al_2 O_3$, $2Si O_2$, $2H_2O$, (Scacchi) $(Ca O, Na O)^3 Si O_3 + 3Al_2 O_3 + 7H_2O$ = silica 37.4, alumina 31.8, lime 13.0, soda 4.8, water 13 = 100.

Crystallisation, Rhombic, but it generally occurs in masses with a columnar or radiated structure. Hardness 5—5.5, Specific Gravity 2.35—2.4. Snow white, or colourless. Transparent to translucent. Brittle, with an uneven fracture and vitreous lustre. Pyro-electric. Before the blowpipe exhibits the zeolitic intumescence, and gelatinises with acids.

Occurs in basalt in various localities in Scotland and Ireland, in the Faröe Islands, Sicily, Bohemia, &c. At Vesuvius it is in the ejected lavas of Monte Somma frequently associated with Phillipsite, but rather rare in the conglomerates.

Etymology: The Vesuvian mineral was named Comptonite by Brewster after Lord Compton, by whom it was first distinguished, but the name Thomsonite, after Prof. Thomson, of Glasgow, was given to Scotch specimens by Brooke a year previously.

Titanite, Klaproth (Titanite), Sphene, Semeline, Ligurite.

Silicate of Titanium and Lime, $Ti O_2 Si O_2 + Ca O Si O_2$ = silica 35, titanic acid 33, lime 32 = 100.

Crystallisation, Monoclinic, often in twinned crystals and sometimes in double twins. It also occurs massive, compact, and, though rarely, lamellar. Hardness 5—5.5, Specific Gravity 3.4—3.56. The

colour varies from dark brown to light yellow (Sphene), with an adamantine to resinous lustre and a whitish streak. It is transparent to opaque, and brittle, with an imperfect conchoidal fracture, and possesses double refractive powers. Decomposed by hydrochloric, hydrofluoric, and sulphuric acids, with separation of gelatinous Silica, and before the blowpipe fuses after intumescence to a yellow or dark-coloured glass.

In the British Islands, Titanite occurs at Strontian and other localities in Scotland, and also in Devonshire, Wales, and Ireland. At Vesuvius it is in small crystals (Semeline), but not common, in the crystalline blocks of Somma rich in orthoclase.

Etymology: Sphene is from σφήν, a wedge, from the shape of its crystals.

VESBINE, A. Scacchi (Vesbina).

Vanadate of Alumina? ($Al_2 O_3 VO_3$).

This substance forms thin yellow crusts on the lava of the eruption of Vesuvius in 1631, and was thought by Prof. Scacchi to contain a new chemical element which he named "Vesbium" (Att. Accad. Napoli, Dec. 13, 1879). In "Lo Spettatore" (1887), however, the Professor describes Vesbine as probably, but not positively, a vanadate of alumina, or a compound of alumina with vanadic acid.

VESUVIANITE, Werner (Idocrasia), Idocrase.

Silicate of Lime and Alumina with Iron and Magnesia = ($3Ca O + Al_2 O_3$) $3Si O_2 + Mg O +$ $Fe O$ = silica 37.50, lime 33.75, alumina 18.50,

magnesia 4.0, iron oxide 6.25 = 100. Three analyses of Vesuvian specimens gave :—

By	Silica.	Lime.	Alumina.	Magnesia.	Iron Oxide.
Magnus	37.36	29.68	23.53	5.21 (with Mn O)	3.99
Karsten	37.50	33.71	18.50	3.10. + .10 of Mn O	6.25
Scheerer	37.80	32.11	12.11	7.11 (with trace of MnO)	9.36 with [1.67 water

Crystallises in the Square Prismatic System, and occurs also massive. The crystals are usually rectangular prisms, terminated by planes, the angles of the prism being often replaced. Hardness 6.5, Specific Gravity 3.349—3.45. Colour brown to green, sometimes yellow and sometimes blue (the Vesuvian mineral being hair-brown or olive-green), with a lustre vitreous, inclining to resinous, and a white streak. Translucent and sometimes nearly transparent, and is doubly refractive. Fracture, subconchoidal. This mineral is partly decomposible by hydrochloric acid, and entirely so after fusion, when it gelatinises. Fusion is easily produced by the blowpipe with intumescence, when a glass is produced, which is with microcosmic salt opalescent. Stones for jewellery are cut from Vesuvianite in Italy, and called by various names according to their colour.

In the British Islands the mineral occurs in Aberdeenshire and Skye in Scotland, and in Donegal in Ireland. In Finland it is called *Frugardite*, *Gokumite*, and *Loboite ;* in Norway, *Cyprine ;* and in Bohemia, *Egeran.* At its chief locality, Vesuvius, it is of frequent occurrence in the

crystalline masses of Monte Somma, associated with biotite and garnets.

Named Vesuvian by Werner from its original and chief locality, and called Idocrase by Haüy, Phillips, and other mineralogists, from εἶδω, to seem, and κρᾶσις, a mixture, from its crystalline forms being mixed figures and often mistaken for others.

WAGNERITE (Crifiolite).

Fluophosphate of Magnesia = $Mg\ O_3\ P\ O_5 + Mg\ F$ = phosphoric acid 43.8, magnesia 37.1, fluorine 11.7, magnesium 7.4 = 100.

Crystallisation, Cubic, occurs in complex crystals with vertical striæ. Hardness 5—5.5, Specific Gravity 2.985 (untransparent)—3.068 (transparent). Colour yellow, of various tints, and sometimes greyish. Translucent, with a vitreous lustre and an uneven and splintery fracture across the prism. When powdered it dissolves slowly in warm nitric and sulphuric acid, giving off fumes of hydrofluoric acid.

Occurs in quartz veins in clay-slate near Salzburg, in Austria. At Vesuvius it was found in a mass of old volcanic rock enveloped in the lava of 1872.

Etymology: Named after Von Wagner, Director of Mines in Bavaria.

WOLLASTONITE, Stutz (Vollastonite), Tabular Spar.

Silicate of Lime, $Ca\ O\ Si\ O_2$ = silica 51.7, lime 48.3 = 100. An analysis of Wollastonite from Vesuvius by Wiehagen gave: Silica 51.90, lime 46.44, magnesia 0.65, protoxide of iron with manganese 0.96 = 99.95.

Crystallisation, Monoclinic, but rarely in distinct tabular crystals. It occurs usually in lamellar, granular, or columnar masses. Hardness 4.5—5, Specific Gravity 2.785—2.895. Colour white or tinged with grey, yellow, or red. Sub-transparent to translucent, with a vitreous lustre. It is sometimes very tough and sometimes rather brittle, with an uneven fracture, and becomes phosphorescent by heat or when scratched with a knife. Wollastonite is decomposed by hydrochloric acid, with the production of gelatinous Silica, but fuses with difficulty to a semi-transparent glass.

It occurs in Aberdeenshire with Vesuvianite, and in the north of Ireland, where it has a somewhat fibrous structure. At Vesuvius, the lamellar Wollastonite is common in the crystalline masses of Somma.

Named after Dr. Wollaston.

Zircon, Werner (Zircone), Jargon.

Silicate of Zirconia, $Zr\ O_2\ Si\ O_2$ = silica 33, zirconia 67 = 100.

Crystallisation, Square Prismatic in quadrangular crystals, terminated by pyramids, resembling those of Cassiterite, and also in rounded grains. Hardness 7.5, Specific Gravity 4—4.75. Colourless, grey, and various shades of yellow and brown, sometimes, but rarely, white. It is transparent to opaque, with double refraction and variable adamantine lustre. The streak is white, and the fracture conchoidal. Zircon is only with difficulty soluble in concentrated

sulphuric acid, and in other acids it is not acted upon. It is also infusible when alone before the blowpipe, but with a large quantity of borax it fuses with difficulty.

In the British Islands, Zircon occurs at Strontian, Argyleshire, in the Island of Harris, and in Ireland at Croghan, Kinshela Mountain. At Vesuvius it is rare in the glassy felspar of the crystalline ejections of Somma.

Etymology: From the Arabic *zerk*, meaning a precious stone.

INDEX OF SYNONYMS AND INCLUDED VARIETIES.

Acido cloridico	*see* Hydrochloric acid gas.
Actinolite	,, Amphibole.
Adularia	,, Orthoclase.
Aftalosa	,, Aphthitalite.
Agate	,, Quartz.
Alabaster	,, Gypsum.
Alite	,, Halite.
Almandine	,, Spinelle.
Alume	,, Alum.
Amazon stone	,, Orthoclase.
Amethyst	,, Quartz.
Amianthus	,, Amphibole.
Amphigene	,, Leucite.
Andridite	,, Garnet.
Anfibolo	,, Amphibole.
Anglesine	,, Anglesite.
Anhydrous sulphate of copper	,, Dolerophanite.
Anidride carbonica	,, Carbonic acid gas.
Anidride solforosa	,, Sulphurous acid gas.
Anidrite	,, Anhydrite.
Anortite	,, Anorthite.

Aragon spath	*see* Aragonite.
Arcanite	„ Aphthitalite.
Asbestos	„ Amphibole.
Asparagus stone	„ Apatite.
Atelina	„ Atelite.
Augite	„ Pyroxene.
Auina	„ Haüynite.
Auripigmentum	„ Orpiment.
Ausmannite	„ Hausmannite.
Azoturo di ferro	„ Ferric nitrate.
Azurite	„ Chessylite.
Azzurrite	„ Chessylite.
Beaudantite	„ Sommite.
Belonesia	„ Belonesite.
Bischofite	„ Chloromagnesite.
Bitter spar	„ Dolomite.
Black Jack	„ Blende.
Black lead	„ Graphite.
Blue carbonate of copper	„ Chessylite.
Blue copper	„ Chessylite.
Blue John	„ Fluorite.
Blue vitriol	„ Cyanosite.
Boracic acid	„ Sassolite
Bristol diamonds	„ Quartz.
Cairngorm	„ Quartz.
Calcantite	„ Cyanosite.
Calcareous spar	„ Calcite.
Calce	„ Calcite.
Capillary pyrites	„ Millerite.
Carbonate of lime	„ Calcite.
Carbuncle	„ Garnet.
Carnelian	„ Quartz.
Cavolinite	„ Sommite.
Chalcanthite	„ Cyanosite.
Chalcedony	„ Quartz.
Chert	„ Quartz.
Chloride of calcium	„ Chlorocalcite.
Chloride of iron	„ Molysite.
Chloride of lead	„ Cotunnite.

Chloride of magnesia	*see* Scacchite.
Chloride of sodium	,, Halite.
Chondrodite	,, Humite and Chondrotite.
Christianite	,, Anorthite.
Chrysoprase	,, Quartz.
Cianocroma	,, Cyanochroite.
Cianosa	,, Cyanosite.
Clinohumite	,, Humite and Clinohumite.
Cloralluminio	,, Chloralluminite.
Clorammonio	,, Sal ammoniac.
Clorocalcite	,, Chlorocalcite.
Cloromagnesite	,, Chloromagnesite.
Clorotionite	,, Chlorotionite.
Common felspar	,, Orthoclase.
Common salt	,, Halite.
Comptonite	,, Thomsonite
Copper vitriol	,, Cyanosite.
Cotunnia	,, Cotunnite.
Covellina	,, Covellite.
Covelline	,, Covellite.
Covellinite	, Covellite.
Crifiolite	,, Wagnerite.
Criptoalite	,, Cryptohalite.
Cubic zeolite	,, Analcime.
Cupreous sulphate of lead	,, Linarite.
Cuspidina	,, Cuspidine.
Davyne	,, Sommite.
Derbyshire spar	,, Fluorite.
Diallage	,, Pyroxene.
Dolerofano	,, Dolerophanite.
Dolomie	,, Dolomite.
Edenite	,, Amphibole.
Elæolite	,, Sommite.
Ematite	,, Hæmatite.
Epidote	,, Pyroxene.
Epsom salts	,, Epsomite.
Eriocalco	,, Eriochalcite.
Eritrosidero	,, Erithrosiderite.
Euclorina	,, Euchlorinite.

Exantalosa	*see* Exanthalose and Mirabilite.
Fassaite	,, Pyroxene.
Felspar	,, Orthoclase.
Fillipsite	,, Phillipsite.
Flint	,, Quartz.
Flos ferri	,, Aragonite.
Fluor spar	,, Fluorite.
Fluoride of calcium	,, Fluorite.
Galena	,, Galenite.
Gelenite	,, Melilite.
Gesso	,, Gypsum.
Glaserite	,, Ophthitalite.
Glauber salt	,, Mirabilite.
Grafite	,, Graphite.
Grammatite	,, Amphibole.
Granato	,, Garnet.
Grossularite	,, Garnet.
Hälleflinta	,, Orthoclase.
Haüyna	,, Haüynite.
Haüyne	,, Haüynite.
Heliotrope	,, Quartz.
Hornblende	,, Amphibole.
Humboldtilite	,, Melilite.
Hydrofluoric acid	,, Hydrofluorite.
Iceland spar	,, Calcite.
Idocrase	,, Vesuvianite.
Idocrasia	,, Vesuvianite.
Idrociano	,, Hydrocyanite.
Idrodolomite	,, Hydrodolomite.
Idrofluore	,, Hydrofluorite.
Idrogeno solforato	,, Sulphuretted hydrogen gas.
Idrogiobertite	,, Hydromagnesite.
Indigo copper	,, Covellite.
Iron glance	,, Hæmatite.
Iron pyrites	,, Pyrite.
Jade	,, Amphibole.
Jargon	,, Zircon.
Jasper	,, Quartz.
Jeffersonite	,, Pyroxene.

Kalinite	*see* Alum.
Kupferlasur	,, Chessylite.
Labrador felspar	,, Labradorite.
Lapislazuli	,, Lapis Lazuli.
Latialite	,, Haüynite.
Ligurite	,, Titanite.
Lime felspar	,, Labradorite.
Litidionite	,, Lithidionite.
Lode stone	,, Magnetite.
Loxoclase	,, Orthoclase.
Lydian stone	,, Quartz.
Magnesia mica	,, Biotite.
Magnesian carbonate of lime	,, Dolomite.
Magnetic iron ore	,, Magnetite.
Magnetic pyrites	,, Pyrrhotite.
Magnoferrite	,, Magnesioferrite.
Marcasite	,, Pyrite.
Melacolite	,, Pyroxene.
Melaconite	,, Tenorite.
Melanotallo	,, Melanothallite.
Mellilite	,, Melilite.
Meroxene	,, Biotite.
Mica	,, Biotite.
Microlin	,, Orthoclase.
Molibdenite	,, Molybdenite.
Molisite	,, Molysite.
Molybdena	,, Molybdenite.
Molybdate of magnesia ?	,, Belonesite.
Moonstone	,, Orthoclase.
Moroxite	,, Apatite.
Mountain leather	,, Amphibole.
Mundic	,, Pyrite.
Murchisonite	,, Orthoclase.
Muriate of ammonia	,, Sal ammoniac.
Muriate of copper	,, Atacamite and Eriochalcite.
Mussite	,, Pyroxene.
Native alum	,, Alum.
Native sedative salt	,, Sassolite.
Native ultramarine	,, Lapis Lazuli.

Necronite	*see* Orthoclase.
Necrociano	,, Necrocyanite.
Neocrisolite	,, Neochrysolite.
Nepheline	,, Sommite.
Nephelite	,, Sommite.
Nephrite	,, Amphibole.
Oil of vitriol	,, Sulphatite.
Olivine	,, Chrysolite.
Onyx	,, Quartz.
Opal	,, Quartz.
Orpimento	,, Orpiment.
Orthoclase felspar	,, Orthoclase.
Ortoclasia	,, Orthoclase.
Pearlspar	,, Dolomite.
Pebble	,, Quartz.
Periclasia	,, Periclasite.
Peridote	,, Chrysolite.
Peridoto	,, Chrysolite.
Peroxide of iron	,, Hæmatite and Limonite.
Perthite	,, Orthoclase.
Phosphorite	,, Apatite.
Picromeride	,, Picromerite.
Pierre d'Arquebuse	,, Pyrite.
Pirite	,, Pyrite.
Pirossene	,, Pyroxene.
Pirotecnite	,, Thenardite.
Pirrotina	,, Pyrrhotite
Plagioclasia	,, Labradorite.
Pleonaste	,, Spinel.
Plumbago	,, Graphite.
Potash alum	,, Alum.
Potash felspar	,, Orthoclase.
Proidonina	,, Proidonite.
Protoxide of copper	,, Tenorite.
Pseudocotunnia	,, Pseudocotunnite.
Pyrites	,, Pyrite.
Pyrope	,, Garnet.
Pyrrhotine	,, Pyrrhotite,
Quarzo	,, Quartz.

Raucierite	*see* Hausmannite.
Rautenspath	,, Dolomite.
Red arsenic	,, Realgar.
Red copper	,, Cuprite.
Red iron ore	,, Hæmatite.
Red oxide of iron	,, Hæmatite.
Red sulphuret of arsenic	,, Realgar.
Risagallo	,, Realgar.
Rock cork	,, Amphibole.
Rock crystal	,, Quartz.
Rock salt	,, Halite.
Ruberite	,, Cuprite.
Rubicelle	,, Spinel.
Sahlite	,, Pyroxene.
Salmiac	,, Sal ammoniac.
Sanidine	,, Orthoclase.
Sapphairos	,, Lapis Lazuli.
Sard	,, Quartz.
Sardonyx	,, Quartz.
Sassolino	,, Sassolite.
Satin spar	,, Aragonite and Gypsum.
Schiller spar	,, Pyroxene.
Scolezite	,, Scolecite
Silica	,, Quartz.
Selenite	,, Gypsum.
Semolina	,, Titanite.
Siliceous sinter	,, Quartz.
Silicified wood	,, Quartz.
Skolezit	,, Scollecite.
Smaragdus	,, Chrysolite.
Solfatite	,, Sulphatite.
Solfato manganoso	,, Sulphate of manganese.
Somervillite	,, Melilite.
Sphalerite	,, Blende.
Sphene	,, Titanite.
Spinello	,, Spinel.
Sulphate of copper	,, Cyanosite.
Sulphate of lead	,, Anglesite.
Sulphate of lime	,, Gypsum.

Sulphate of magnesia	*see*	Epsomite.
Sulphate of soda	,,	Exanthalose and Thenardite.
Sulphuret of arsenic	,,	Orpiment.
Sulphuret of iron	,,	Pyrite.
Sulphuret of lead	,,	Galenite.
Sulphuret of nickel	,,	Millerite.
Sulphuret of zinc	,,	Blende.
Sulphuric acid	,,	Sulphatite.
Tabular spar	,,	Wollastonite.
Tile ore	,,	Cuprite.
Tremenhurite	,,	Graphite.
Tremolite	,,	Amphibole.
Triclinic felspar	,,	Labradorite.
Umite	,,	Humite.
Uniaxial mica	,,	Biotite.
Uralite	,,	Pyroxene.
Vesuvian salt	,,	Aphthitalite.
Vesbina	,,	Vesbine.
Volcanite	,,	Pyroxene.
Vollastonite	,,	Wollastonite.
White copperas	,,	Coquimbite.
White garnet	,,	Leucite.
Wood opal	,,	Quartz.
Ziguelina	,,	Cuprite.
Zigueline	,,	Cuprite.
Zircone	,,	Zircon.
Zurlite	,,	Melilite.

CHAPTER XI.

THE FLORA OF VESUVIUS.

The Floras of Vesuvius and Capri compared—Cause of difference—Vesuvian Flora very varied—List of Families and Summary of Species—List of Medicinal Plants—Genera of Graminaceæ, Musci, Hepaticæ, and Lichens—List of Species with Habitats, of Ferns and Fungi.

As might be expected from the fertility of the soil and the favourable character of the climate, the Flora of Vesuvius is exceedingly varied and interesting. A very valuable work by Senor Giuseppe Antonio Pasquale was published in Naples in 1869,* for the purpose of demonstrating the effects of difference of soil on vegetation, and with that object the Flora of Vesuvius, produced on volcanic soils, was compared with the Flora of the neighbouring island of Capri, produced by calcareous soils, that island being composed of limestone, and not at all volcanic. From this comparison it appears that no less than twenty-six Vesuvian genera are unknown at Capri. These are the following :—

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* "Flora Vesuviana o Catalogo Ragionato delle Piante del Vesuvio confrontate con quelle dell' Isola di Capri e di altri luoghi circonstanti."

GENERA OF PLANTS ON OR ABOUT VESUVIUS NOT ON THE ISLAND OF CAPRI.

(VESUVIUS, VOLCANIC SOIL; CAPRI, CALCAREOUS.)

Aristolochia.	Humulus.
Cephalanthera.	Imperata.
Cheilanthes.	Lilium.
Coscinodon.	Limodorum.
Cystopteris.	Lycium.
Daphne.	Pleuridium.
Enthostadon.	Pogonatum.
Ehrharta.	Saccharum.
Epipactis.	Senebiera.
Fabronia.	Stereocaulon.
Genista.	Tilia.
Glechoma.	Webera.
Habrodon.	Zygodon.

Altogether, no less than 934 species and 326 varieties of plants are enumerated as growing on the slopes and flanks and immediate surroundings of the volcano. These range from the noble oak and chestnut to the lowly lichen, the *Stereocaulon Vesuvianum*, that is found on recent lavas, and is the first plant to grow on the products of Vesuvius.

The grape vine, the *Vitis vinifera*, may be said to be the chief Vesuvian plant, for it clothes the great proportion of the Vesuvian cultivated area. Of the fruit of the *Vitis vinifera*, as many as 97 sorts of grapes are produced in the vineyards around Vesuvius, of which 32 are white, 57 black, and 8 are of shades of red and violet.

About twenty varieties of pears, and more than that number of apples are cultivated, and there are

all the ordinary south-temperate as well as sub-tropical fruits: Almonds, figs, olives, peaches, apricots, cherries, plums, mulberries, and the following species of orange and lemon: *Citrus bigardia*, *C. aurantium*, *C. medica*, *C. limonum*, *C. limetta*, and *C. deliciosa*.

Of ordinary timber trees there are growing luxuriantly the oak (both *Quercus robur* and *Q. Ilex*), the elm, the lime, the poplar (*P. alba*, *P. nigra*, and *P. tremula*), the acacia, the willow, the birch, the chestnut (which, with the broom, the *Genista tinctoria*, clothes elevated tracts on Monte Somma), the walnut, the maple, the alder, the hornbean, with the flowering thorn (the *Celtis australis*), the hazel, three species of *Pinus*, and the *Cupressus sempervirens*. The cactus also flourishes with the myrtle, laurel, &c. Seven species of rose are found, and many varieties are cultivated. Culinary vegetables are grown in abundance, and Signor Pasquale enumerates 75 species of Graminaceæ. The date palm grows, and produces fruit, but not eatable.

The following is a summary of the results arrived at by the investigations of Signor Pasquale:—

DICOTYLEDONES.

Thalamiflorœ.					
Ranunculaceæ	...	...	12	Resedaceæ	...	...	1
Papaveraceæ	...	...	3	Cistineæ	...	...	4
Fumariaceæ	...	...	4	Violariæ	...	...	4
Cruciferæ	...	...	26	Caryophylleæ	...	...	23
Capparideæ	...	...	1	Lineæ	...	...	2
				Malvaceæ	...	...	5

Aurantiaceæ	6
Tiliaceæ	1
Hypericineæ	4
Ocerineæ	2
Ampelideæ	1
Geraniaceæ	7
Oxalideæ	2
Zygophylleæ	1
Rutaceæ	1

Calyciflorœ polypetalæ.

Rhamneæ	2
Celastrineæ	1
Terebinthaceæ	1
Zanthoxyleæ	1
Leguminosæ	84
Amygdaleæ	12
Rosaceæ	16
Pomaceæ	9
Onagrariæ	1
Myrtaceæ	1
Granateæ	1
Cucurbitaceæ	4
Portulaceæ	1
Paronychieæ	4
Crassulaceæ	7
Ficoideæ	1
Cactaceæ	1
Saxifragaceæ	4
Umbelliferæ	21
Loranthaceæ	1
Araliaceæ	1

Calyciflorœ gamopetalæ.

Corneæ	1
Caprifoliaceæ	3
Rubiaceæ	10
Valerianeæ	1
Dipsaceæ	2
Compositæ	89
Campanulaceæ	6
Ebenaceæ	2
Ericaceæ	2

Corolliflorœ.

Primulaceæ	5
Oleaceæ	4
Apocynaceæ	3
Asclepiadeæ	1
Gentianeæ	3
Convolvulaceæ	3
Borragineæ	12
Solanaceæ	17
Scrophularineæ	23
Orobancheæ	7
Acanthaceæ	1
Verbenaceæ	2
Labiatæ	31
Plantagineæ	7

Monochlamydeæ.

Phytolaccaceæ	1
Amarantaceæ	4
Chenopodiaceæ	8
Nyctagineæ	1
Polygoneæ	9
Laurineæ	1
Aristolochieæ	1
Santalaceæ	1
Cytineæ	1
Euphorbiaceæ	7
Urticaceæ	6
Moreæ	11
Cannabineæ	2

Celtideæ	1	Betulaceæ	3
Ulmaceæ	1	Salicineæ	6
Juglandeæ	1	Coniferæ	4
Cupuliferæ...	4		

MONOCOTYLEDONES.

Aroideæ	2	Dioscoreæ	1
Lemnaceæ	1	Smilaceæ	6
Palmæ	1	Liliaceæ	11
Orchidaceæ	13	Juncaceæ	5
Irideæ	5	Cyperaceæ	6
Amaryllidæ	4	Graminaceæ	75

ACOTYLEDONES.

Vasculares.		*Cellulares.*	
Ophioglosseæ	1	Musci	69
Lycopodiaceæ	1	Hepaticæ	25
Polypodiaceæ	11	Lichenes	33
		Fungi	56

In "Lo Spettatore del Vesuvio" there is a highly interesting contribution from Signor Orazio Comes, of the Botanical Laboratory of the Royal School of Agriculture at Portici, "Le Lave il Terreno Vesuviano e la loro Vegetazione," in which it is stated that the following medicinal plants may be gathered on Vesuvius. In giving this list Signor Comes remarks that it strikingly corroborates a statement by Bracini, that in his time the Atrio del Cavallo was a veritable garden of simples.

LIST OF MEDICINAL PLANTS GROWING ON VESUVIUS.

Androsaemum officinale.	Campanula Rapunculus.
Asparagus acutifolius.	Chelidonium majus.
Artemisia arborescens.	Clematis vitalba.

Cornus sanguinea.
Cistus saloifolius.
Datura stramonium.
Delphinium cardiopetalum.
Erythræa centaurium.
Genista tinctoria.
Geranium Robertianum.
Helleborus fœtidus.
Helianthemum vulgare.
Hypericum perforatum.
Hyoscyamus albus.
Inula viscosa.
Melissa officinalis.
Mercurialis annua.
Origanum vulgare.
Orchis maculata.
Phytolacca decandra.
Plantago major.
Pistacia Lentiscus.
Psoralea bituminosa.
Rosa canina.
Ranunculus lanuginosus.
Reseda fruticulosa.
Ruscus aculeatus.
Saponaria officinalis.
Sambucus nigra.
Scabiosa columbaria.
Smilax aspera.
Thymus acynos.
Tamus communis.
Teucrium chamædrys.
Tussilago farfara.
Urtica dioica.
Verbascum thapsus.
Viola odorata.
Vinca major.

The large number of forms of the lower orders of plants is also remarkable, since it appears from the "Flora Vesuviana" that there are 75 species of Graminaceæ, 69 of Mosses, 25 of Hepaticæ, 33 of Lichens, and 56 species of Fungi.

The following are the genera of the Graminaceæ:—

Ægylops.
Alopecurus.
Ampelodesmos.
Andropogon.
Anthoxanthum.
Arundo.
Avena.
Brachypodium.
Briza.
Bromus.
Calamagrostis.
Catapodium.
Chrysurus.
Corynephorus.
Cynodon.
Cynosurus.
Dactylis.
Digitaria.
Echinochloa.
Ehrharta.
Eragrostis.
Festuca.

Gaudinia.
Holcus.
Hordeum.
Imperata.
Koeleria.
Lolium.
Melica.
Phleum.
Poa.
Psilurus.
Rottbœlia.
Saccharum.
Sclerochloa.
Secale.
Sesleria.
Setaria.
Sorghum.
Trisetum.
Triticum.
Zea.

The genera of the Musci are—

Anacalypta.
Bartramia.
Bryum.
Coscinodon.
Cryphæa.
Dicranum.
Eucalypta.
Fabronia.
Fissideus.
Funaria.
Grimmia.
Gymnosternum.
Habrodon.
Hypnum.
Leptodon.
Leskea.
Leucodon.
Muium.
Orthotrichum.
Phascum.
Philonotis.
Physcomitrium.
Pleuridium.
Pogonatum.
Pterigynandrum.
Pterogonium.
Trichostomum.
Webera.
Weisia.
Zygodon.

The genera of the Hepaticæ are—

Anthoceros.
Corsinia.
Jungermannia.
Lunularia.
Marchantia.
Riccia.
Sphærocarpus.
Targionia.

The genera of the Lichens are—

Cladonia.
Collema.
Lecidia.
Lepra.
Opegrapha.
Parmelia.
Peltigera.
Ramalina.
Stereocaulon.

Ferns and Fungi are now so frequently sought for and collected that the following lists of Vesuvian species of these interesting and beautiful though lowly plants, with their habitats and localities, may prove useful to visitors to Naples who have time and opportunity to explore the lower slopes and immediate neighbourhood of the mountain. The lists are compiled from the information given by Signor Pasquale in the "Flora Vesuviana."

FERNS.

Adiantum capillus Veneris, Lin.—In grottos, hollows, and steep paths.

Aspidium aculeatum, Sw.—Hedges, borders of woods, and most commonly in hollows. Camaldoli, Canteroni, Somma, &c.

A. pallidum, Bory.—Very rare in the Vesuvian district, once found on the lavas near the Chapel of S. Vito, and in shady valley bottoms, where it is very large. Somma, S. Anastasia.

Asplenium Adiantum nigrum, Lin.—Rocks and walls in shady places, and also common in plantations.

,, var. acutum, Ten.

A. trichomanes, Lin.—Stones, walls, and lavas in low-lying places.

Ceterach officinarum, D.C.—Stones and walls of vineyards, most commonly attached to stones.

Cheilanthes odora, Sw.—In the middle zone of Vesuvius, on walls and rocks. Strada vecchia del Salvatore, S. Vito, Tironi, and abundant in the Vallone di Tironcelli di Torre del Greco.

Cystopteris fragilis, Guss.—Once found on the moist northern face of a rock on the summit of Monte Somma, near to the Punta Nasione, not elsewhere, therefore very rare a Vesuvius.

Grammitis leptophylla, Sw.—Wayside mounds and shady fields, and also common in cavities.

Ophioglossum lusitanicum, Lin.—In open seaside meadows at Granatello di Portici, not elsewhere.

Polypodium vulgare, Lin.—Most commonly on exposed walls.

Pteris aquilina, Lin.—More abundant on the northern than on the southern side of the mountain. Somma, Monticello a Torre del Greco, &c.

FUNGI.

Agaricus ægirita, Brig.—Old Poplars and the Celtis Australis.
,, amethystæus, Bull.—Chinks of rocks filled with earth, Somma.
,, androsaceus, Lin.—Withered leaves of the Olive after autumnal rains, Portici, Resina, Somma.
,, auricolor, Brig.—Grove by a villa at Portici.
,, Cæsareus, Scop.—Plantations, S. Anastasia.
,, campestris, var. edulis.—Rich Olive groves, Tironcelli di Torre del Greco.
,, ,, var. pratensis.
,, ,, var. sylvicola.—Open cultivated land.
,, fascicularis, Pers.—Rich gardens, Royal Park of Portici.
,, fucatus, Fr.—Cultivated land and meadows.
,, medusa, Brig.—Orange groves.
,, melleus, Vahl.—Common at the base of neglected and uprooted trees.
,, ,, var. vitis, Brig.—Vines after the autumn rains.
,, ,, var. citra, Pas.—Trunks of Orange trees.
,, mucida, Brig.—Almond husks, Portici.
,, oreades, Bolt.—Common in grassy places.
,, ovoideus, Bull.—Plantations, Somma, S. Anastasia.
,, ,, var. leucosarcos, Brig.
,, ruber, Schœff.—Chestnut woods.
,, rotula, Scop.—Stalks of Nepeta, mint.
,, solitarius, Bull.
,, strobiloides, Brig.—Trunks of trees and cultivated land.
,, Vesuvianus, Brig.—Dry and open land, Portici.
Boletus edulis, Bull.—Plantations, Somma, Ottajano, &c.
,, luridus, Schœff.—Accompanies B. edulis, Somma.

Cantharellus cibarius, Fries.—Plentiful in oak and chestnut woods on Monte Somma, and also still more abundant in groves at Barra, Royal Park of Portici, Parco di Bisignano, &c.

Capuodium citri, Bakl.—Foliage of Orange trees.

Clathrus cancellatus, Lin.—Rich soils, Royal Parks of Portici and La Favorita.

Clavaria flava, Pers.—Groves with moisture, Royal Parks of Portici and La Favorita, and the Parco Bisignano at Barra.

Cyathus olla, Pers.—Cultivated land on dry litter.

Dædalea quercina, Pers.—Base of tree trunks, wood yards of Torre del Greco.

,, sepiaria, Fries.—Ilex trees, Royal Park of Portici.

Exidia auricula, Judæ.—Dead trees.

Geastrum hygrometricum, Pers.—Gravelly or sandy exposed plantations, Bosco di Mauro, Camaldoli della Torre.

Graphiola Phœnicis, Poit.—Portici.

Helvella esculenta, Pers.—Common in vineyards, most abundant about the vines, Somma, Resina, &c.

Hydnum repandum, Lin.—Groves, Royal Park of Portici, Parco di Bisignano.

Lycoperdon bovista, Lin.—Sandy damp plantations, Mauro, Torre del Greco.

Morchella esculenta, Pers.—Cultivated ground.

,, conica, Pers.—Cultivated ground.

,, semilibera, D.C.—Vineyards, S. Anastasia.

Mœmaspora aurea, Fr.—Dry trunks of Poplars, sunny spots of Vesuvius, Portici, Bagnoli.

Oidium Tuckeri, Berckel.—A pest of the vine, appeared first in 1851.

,, leuconium, Desm.—Indian rose.

,, ,, var. cucurbita, Gaspar

,, ,, var. ranunculi, Gaspar.

,, erisyphoides, Fr.

Peziza aurantia, Pers.—Both on the ground and on the trees, Royal parks.

,, cerea, Sow.

,, hemisphærica, Fl.

Peziza vesiculosa, Grev.—Decayed leaves of the ilex, Royal Park of Portici.

Phallus impudicus, Lin.—Richly cultivated lands.

Polyporus conchatus, Fries.—Ilex trees in shady places, Royal Park of Portici.

„ frondosus, Fries.—Somma, S. Anastasia.

„ perennis, Fr.—Very common, and always on the ground in unproductive plantations.

„ ribis, D.C.—Base of the Cratægi Azarolli (thorn), common at the bottom of the Indian Rose trees, Royal Parks of Portici.

„ squamosus, Fr.—On the oldest Paper Mulberry trees in groves.

„ versicolor, Fr.—Common on dry trees.

Polysaccum pisocarpum, Fr.—Sandy, sunny places amongst underwood, Mauro, Torre del Greco.

Scleroderma corium, Graves.—In sandy, exposed plantations Mauro, Torre del Greco.

Sphæria typhina, Pers.—On the end of the Dactylis hispanicæ in plantations, Camaldoli.

Uredo candida, Pers.—Shoots of Bursa pastoris.

„ leguminosarum.—On several sorts of vegetables.

„ rosæ, Pers.—On the foliage of the Dog Rose.

„ symphyti, D.C.—Borders of woods in dells.

APPENDIX.

LETTERS OF PLINY THE YOUNGER,

CONTAINING AN ACCOUNT OF THE ERUPTION OF A.D. 79. FROM "THE LETTERS OF PLINY THE YOUNGER." BY JOHN EARL OF ORRERY.

PLINIUS CÆCILIUS SECUNDUS (CAIUS) *to* CORNELIUS TACITUS.

(Book VI., Epistle XVI.)

YOU are desirous that I should give you an account of the death of my uncle, that you may be enabled to transmit it to posterity with the greater truth. I return you thanks. I foresee that his death when celebrated by you must procure eternal honour to his name; for although his fall was attended by the destruction of most beautiful territories, seeming, as it were, destined to be remembered equally with those nations and cities who perish by some memorable event; although he had compiled works both numerous and lasting, yet the immortality of your writings will lengthen out the character which he has established to himself. I consider it as a blessing to be possessed of endowments which either qualify us for actions worthy of public record, or inspire us to write anything worthy of public attention. But I think those persons peculiarly favoured from heaven who obtain both these qualifications. My uncle by his own works and by yours may be numbered among these last, for which reason I more readily undertake, and even wish for, the employment that you enjoin.

He was at Misenum, where he had the command of a fleet which was stationed there. On the ninth of the calends of September, about the seventh hour, my mother informed him that a cloud appeared of unusual size and shape. After having reposed himself in the sun, and used the cold bath—he had tasted a slight repast, and was returned to his studies—he immediately called for his sandals, and repaired to a higher point of view, from whence he might more plainly discern this prodigy. The cloud (the spectators could not distinguish at a distance from what mountain it arose, but it was afterwards found to be Vesuvius) advanced in height; nor can I give you a more just representation of it than the form of a pine-tree, for springing up in a direct line, like a tall trunk, the branches were widely distended. I believe, while the vapour was fresh, it more easily ascended; but when that vapour was wasted the cloud became loose, or, perhaps oppressed by its own gravity, dilated itself into a greater breadth. It sometimes appeared bright, and sometimes black, or spotted, according to the quantity of earth and ashes mixed with it. This was a surprising circumstance, and it deserved, in the opinion of that learned man, to be inquired into more exactly. He commanded a *Liburnian* galley to be prepared for him, and made me an offer of accompanying him if I pleased. I replied it was more agreeable to me to pursue my studies; and, as it happened, he had allotted me something at that time to write. He went out of the house with his tablets in his hand. The mariners at Retina being under consternation at the approaching danger (for that village was situated under the mountain, nor were there any means of escaping but by sea), entreated him not to venture upon so hazardous an enterprise. He continued firm to his resolution, and performed, with great fortitude of mind, what he had at first undertaken from a thirst of knowledge.

He commanded the galleys to put off from land, and embarked with a design not only to relieve the people of Retinæ but many others in distress, as the shore was interspersed with a variety of pleasant villages. He sailed immediately to places which were abandoned by other people, and boldly held his course in the face of danger, so composed as to remark distinctly

the appearance and progress of this dreadful calamity and to digest and dictate those remarks.

He now found that the ashes beat into the ships much hotter and in greater quantities; and as he drew nearer, pumice-stones, with black flints, burnt and torn up by the flames, broke in upon them. And now the hasty ebb of the sea, and ruins tumbling from the mountain, hindered their nearer approach to the shore. Pausing a little upon this, whether he should not return back, and instigated to it by the pilot, he cries out, "*Fortune assists the brave: let us make the best of our way to* POMPONIANUS," who was then at Stabiæ, and lay opposite to a bay into which the sea, creeping gently along that winding coast, insinuates itself. Pomponianus, although not in immediate peril, yet seeing it plainly and finding it approaching fast, was putting his baggage on board some vessels, with a design of making his escape by sea whenever the contrary wind should abate. My uncle, arriving with a fair wind at this place, embraced, comforted, and encouraged his trembling friend; and to effect this, seemed himself to be under no kind of apprehension, but ordering his servants to carry him to the bath, when he had bathed, went to supper, either with a real cheerfulness, or, what is equally the sign of a great mind, the appearance of it.

In the meantime flames issued from various parts of Mount *Vesuvius*, and spreading wide and towering to a great height, made a vast blaze, the glare and horror of which were still increased by the gloominess of the night.

My uncle, to move the general fear, said that the blaze was occasioned by the villages being on fire which were now deserted by the country people. Then retiring to take his rest, he enjoyed a sound sleep; for being of a gross and corpulent habit of body, he was heard to snore by those who waited upon him. The court beyond which was his apartment by this time was so filled with cinders and pumice-stones that had he continued any longer in his room his passage from it would have been stopped up. Being awakened therefore, he quitted his chamber and returned to Pomponianus and the rest, whose fears had hindered them from sleeping, and who had been upon the watch. They consulted together whether it would be more advisable to keep

under the shelter of that roof or retire into the fields; for the house tottered to and fro, as if it had been shaken from the foundation, by the frequent earthquakes. On the other hand, they dreaded the stones, which, by being burnt into cinders, although they fell with no great weight, yet fell in large quantities. But after considering the different hazards which they run, the advice of going out prevailed. In others, one kind of fear conquered another; in my uncle, one prudential reason only succeeded to another.

They covered their heads with pillows bound with napkins: this was their only defence against the shower of stones. And now, when it was day everywhere else, they were surrounded with darkness blacker and more dismal than night, which however was sometimes dispersed by several flashes and eruptions from the mountain. They agreed to go farther in upon the shore, and to look out from the neighbouring land if they might venture to sea; but the sea continued raging and tempestuous. Then my uncle, laying himself down upon a cloth spread on the ground, called twice for some water, and drank it; but the flames and a stench of sulphur which preceded them obliged others to immediate flight and roused him. He raised himself upon his feet, supported by two servants; but his respiration being stopped, he immediately dropped down, stifled, as I imagine, by the sulphur and grossness of the air. His lungs, as he was narrow chested, were naturally weak and subject to inflammations. When the light returned, which was not till the third day after his death, his body was discovered, untouched by the fire, without any visible hurt, in the dress in which he fell, appearing rather like a person sleeping than like one who was dead.

My mother and I still continued at *Misenum*. But this has no relation to the history, nor did you desire any particulars except those of my uncle's death. I shall therefore finish my letter, adding only that I have sent you all the circumstances which I either saw myself or were communicated to me at a time when the truth of every single incident could be easily recollected. From hence you will select such passages as you shall think proper; for it is one thing to write a letter, another to

compile a history: nor is the difference less between writing to a friend in particular than to the world in general. Farewell.

PLINIUS CÆCILIUS SECUNDUS (CAIUS) *to* CORNELIUS TACITUS.

(Book VI., Epistle XX.)

YOU tell me that my former letter, which at your own desire I wrote to you concerning my uncle's death, has tempted you to inquire not only into the terrors, but the distress I suffered while I was left at *Misenum*, for with that particular my letter concluded.

"I will restrain my tears, and briefly tell." When my uncle was gone from us I employed my time (having stayed behind for that purpose) at my studies. I bathed, went to supper, and had a very imperfect and restless sleep. We had for several preceding days together felt an earthquake, which, being common in *Campania*, did not much alarm us; but the shocks were so violent this particular night that all things around us were not only moved, but seemed upon the brink of destruction. My mother hastened into my bed-chamber, at the moment of time when I was rising with an intention to awaken her if I had found her sleeping. We retired into a little court which lay between the house and the sea. I am in doubt whether my conduct ought to be called fortitude or thoughtlessness upon this occasion, for I was then but eighteen years of age. I called for a "*Livy*," and read it as if I had been quite at ease: and, in the manner I had begun, went so far as to select passages from that author.

A friend of my uncle's, who was lately come from *Spain* on purpose to see him, finding my mother and me sitting thus together, and taking notice that I was reading, reproved the patience of her temper and the indifference of mine. However, I still continued intent upon my book. It was now six o'clock in the morning, yet there was but a faint and glimmering light. The house shook violently; and though we were in an open court, yet, as it was very narrow and built almost all round, we were certainly in great danger. We then thought it expedient

to eave the town: the people, distracted with fears, followed us, and (such is the nature of fear which embraces, as most prudential any other dictate in preference to its own) they pressed upon us and drove us forward. When we were out of reach of the buildings we stopped; our astonishment was great, nor were our apprehensions less, for the carriages which we had ordered out of the town were so violently shaken from side to side, although upon plain ground, that they could not be kept in their places even when propped by heavy stones. The sea, too, seemed to be forced back upon itself, repelled as it were by the strong concussions of the earth. It is certain that the shore was greatly widened, and many sea-animals were left upon the strand.

On the land side a dark and horrible cloud, charged with combustible matter, suddenly broke and shot forth a long trail of fire, in the nature of lightning, but in larger flashes. Then my uncle's friend, the same who came out of *Spain*, said to us, with great vehemence and eagerness, "If your brother and your uncle be still living, his wishes are employed for your safety. If he has lost his life, he was desirous yours might be saved. Why then will you not immediately leave this place?" We answered that we were not so solicitous for our own as for my uncle's preservation. He then hastily withdrew, running with the utmost expedition from danger. Not long after, the cloud descending covered the whole bay, and we could no longer see the island of *Caprea* or the promontory of *Misenum*. My mother now began to beseech, advise, and command me to make my escape in any manner I could. She observed that as I was young I might easily take my flight; but that she, who was in years and less active, could patiently resign herself to death, in case she was not the occasion of my destruction. My answer was, "I will never attempt at safety if we are not together." And then, leading her by the hand, I assisted her to go faster; she yielded with regret, still angry at herself for delaying me.

The ashes now fell upon us; however, in no great quantities. I looked back. A thick dark vapour just behind us rolled along the ground like a torrent, and followed us. I then said, "Let us turn out of this road, whilst we can see our way, lest the people who crowd after us trample us to death." We had scarce

considered what was to be done, when we were surrounded with darkness, not like the darkness of a cloudy night or when the moon disappears, but such as is in a close room when all light is excluded. You might have heard the shrieks of women, the moans of infants, and the outcries of men. Some were calling for their parents, some for their children, some for their wives: their voices only made them known to each other. Some bewailed their own fate; others the fate of their relations. There were some who, even from a fear of death, prayed to die. Many paid their adorations to the gods; but the greater number were of opinion that the gods no longer existed, and that this night was the final and eternal period of the world. There were others who magnified the real dangers by imaginary and false terrors. Some affirmed that *Misenum* was burnt to the ground. The report, although not true, gained credit.

A little gleam of light now appeared. It was not daylight, but a forewarning of the approach of some fiery vapour—which, however, discharged itself at a distance from us. Darkness immediately succeeded. Then ashes poured down upon us in large quantities, and heavy, which obliged us frequently to rise and brush them off, otherwise we had been smothered or pressed to death by their weight.

I might boast that not one sigh or timorous word broke from me through all this distress, had I not fortified myself with one great consolation—a miserable one indeed—that all nature was perishing with me.

At last this darkness, which now was drawn into the thinness of a cloud or of smoke, went off; true day appeared. The sun shone forth, but pale, as at the time of an eclipse. All objects that offered themselves to our sight (which was yet so weak that we could scarce bear the return of light) were changed, and covered with ashes as thick as snow. At our return to *Misenum*, after having refreshed ourselves, we remained in that suspense and doubt of mind which hope and fear inspire: fear indeed was most prevalent; for the earthquake still continued, and several enthusiasts, by dreadful prophecies, increased their own fears and the fears of others. But although we had undergone many dangers, and dreaded still more, yet we could not be persuaded to

quit the town till we had received some intelligence concerning my uncle.

You will read this account without any intention of making it a part of your history, of which it is by no means worthy; and you must blame yourself for requiring it from me, if you think it not worthy of a letter. Farewell.

THE FORMATION OF MONTE NUOVO IN 1538.

FOUR CONTEMPORARY NARRATIVES.

I.

By MARCO ANTONIO DELLI FALCONI.*

Del' Incendio di Puzzuolo, Marco Antonio delli Falconi all' Illustrissima Signora Marchessa della Padula nel MDXXXVIII.

First, then, will I relate simply and exactly the operations of nature, of which I was either myself an eye-witness, or as they were related to me by those who had been witnesses of them. It is now two years that there have been frequent earthquakes at Puzzuolo, at Naples, and the neighbouring parts; on the day and in the night before the appearance of this eruption, above twenty shocks, great and small, were felt at the above-mentioned places. The eruption made its appearance the 29th September, 1538, the feast of St. Michael the Angel; it was on a Sunday, about an hour in the night; and as I have been informed, they began to see on that spot, between the hot baths or sweating-rooms and Tripergoli, flames of fire, which first made their appearance at the baths, then extended towards Tripergoli, and fixing in the little valley that lies between the Monte Barbaro and the hillock called del Pericolo (which was the road to the lake of Avernus and the baths), in a short time the fire increased to such a degree, that it burst open the earth in this place, and threw up so great a quantity of ashes and pumice-stones mixed with water, as covered the whole country; and in Naples a shower of these

* From the "Campi Phlegræi," by Sir William Hamilton, K.B., F.R.S. Page 70.

ashes and water fell great part of the night. The next morning, which was Monday, and the last of the month, the poor inhabitants of Puzzuolo, struck with so horrible a sight, quitted their habitations, covered with that muddy and black shower, which continued in that country the whole day, flying death, but with faces painted with its colours; some with their children in their arms, some with sacks full of their goods; others leading an ass, loaded with their frightened family, towards Naples; others carrying quantities of birds of various sorts that had fallen dead at the time the eruption began; others again with fish which they had found, and were to be met with in plenty upon the shore, the sea having been at that time considerably dried up.

Don Petro di Toledo, Viceroy of the kingdom, with many gentlemen, went to see so wonderful an appearance; I also, having met with the most honourable and incomparable gentleman, Signor Fabrizio Moramaldo, on the road, went and saw the eruption and the many wonderful effects of it. The sea towards Baia had retired a considerable way; though, from the quantity of ashes and broken pumice-stones thrown up by the eruption, it appeared almost totally dry. I saw likewise two springs in those lately discovered ruins, one before the house that was the Queen's, of hot and salt water; the other of fresh and cold water, on the shore, about 250 paces nearer to the eruption: some say that, still nearer to the spot where the eruption happened, a stream of fresh water issued forth like a little river. Turning towards the place of the eruption, you saw mountains of smoke, part of which was very black and part very white, rise up to a great height; and in the midst of the smoke at times, deep-coloured flames burst forth with huge stones and ashes, and you heard a noise like the discharge of a number of great artillery. It appeared to me as if Typheus and Enceladus from Ischia and Etna with innumerable giants, or those from the Campi Phlægrei (which, according to the opinions of some, were situated in this neighbourhood) were come to wage war again with Jupiter. The natural historians may perhaps reasonably say that the wise poets meant no more by giants than exhalations shut up in the bowels of the earth, which, not finding a free passage, open one by their own force and impulse, and form mountains, as those which

occasioned this eruption have been seen to do; and methought I saw those torrents of burning smoke that Pindar describes in an eruption of Etna, now called Mon Gibello, in Sicily; in imitation of which, as some say, Virgil wrote these lines:—

"Ipse sed horrificis juxta tonat Ætna ruinis," &c.

After the stones and ashes with clouds of thick smoke had been sent up, by the impulse of the fire and windy exhalation (as you see in a great cauldron that boils) into the middle region of the air, overcome by their own natural weight, when from distance the strength they had received from impulse was spent, rejected likewise by the cold and unfriendly region, you saw them fall thick, and by degrees the condensed smoke clear away, raining ashes with water and stones of different sizes, according to the distance from the place; then by degrees, with the same noise and smoke, it threw out stones and ashes again, and so on by fits. This continued two days and nights, when the smoke and force of the fire began to abate. The fourth day, which was Thursday, at 22 o'clock, there was so great an eruption, that as I was in the Gulf of Puzzoli, coming from Ischia, and not far from Misenum, I saw in a short time many columns of smoke shoot up, with the most terrible noise I ever heard, and bending over the sea, came near our boat, which was four miles or more from the place of their birth; and the quantity of ashes, stones, and smoke seemed as if it would cover the whole earth and sea. Stones great and small, and ashes more or less, according to the impulse of the fire and exhalations, began to fall, so that a great part of this country was covered with ashes; and many that have seen it say they reached the vale of Diana, and some parts of Calabria, which are more than 150 miles from Puzzoli. The Friday and Sunday nothing but a little smoke appeared; so that many taking courage went upon the spot, and say that with the stones and ashes thrown up a mountain has been formed in that valley, not less than three miles in circumference, and almost as high as the Monte Barbaro, which is near it, covering the Canettaria, the castle of Tripergoli, all those buildings and the greatest part of the baths that were about them; extending south towards the sea, north as far the lake of Avernus, west to the Sudatory, and

joining east to the foot of the Monte Barbaro ; so that this place has changed its form and face in such a manner as not to be known again : a thing almost incredible to those that have not seen it, that in so short a time so considerable a mountain could have been formed.

On its summit there is a mouth in the form of a cup, which may be a quarter of a mile in circumference, though some say it is as large as our market-place at Naples, from which there issues a constant smoke ; and though I have seen it only at a distance, it appears very great. The Sunday following, which was the 6th of October, many people going to see this phenomenon, and some having ascended half the mountain, others more, about 22 o'clock there happened so sudden and horrid an eruption, with so great a smoke, that many of these people were stifled, some of which could never be found. I have been told that the number of the dead or lost amounted to twenty-four. From that time to this, nothing remarkable happened ; it seems as if the eruption returned periodically like the ague or gout. I believe henceforward it will not have such force, though the eruption of the Sunday was accompanied with showers of ashes and water which fell at Naples, and were seen to extend as far as the mountain of Somma, called Vesuvius by the ancients ; and as I have often remarked the clouds of smoke proceeding from the eruption, moved in a direct line towards that mountain, as if these places had a correspondence and connection one with the other. In the night many beams and columns of fire were seen to proceed from this eruption, and some like flashes of lightning.

We have, then, many circumstances for our observation—the earthquakes, the eruption, the drying up of the sea, the quantity of dead fish and birds, the birth of springs, the showers of ashes with water and without water, the innumerable trees in that whole country, as far as the grotto of Lucullus, torn from their roots, thrown down, and covered with ashes, that it gave one pain to see them ; and as all these effects were produced by the same cause that produces earthquakes, let us first inquire how earthquakes are produced, and from thence we may easily comprehend the cause of the above-mentioned events.

II.

By PIETRO GIACOMO DI TOLEDO.*

The account of the formation of the Monte Nuovo, by Pietro Giacomo di Toledo, is given in a dialogue between the feigned personages of Peregrino and Secessano, the former of which says :—

"It is now two years that this province of Campagna has been afflicted with earthquakes, the country about Puzzuoli much more so than any other parts; but the 27th and 28th of the month of September last, the earthquakes did not cease day or night in the above-mentioned city of Puzzuoli; that plain which lies between the lake of Averno, the Monte Barbaro, and the sea was raised a little, and many cracks were made in it, from some of which issued water; and at the same time the sea, which was very near the plain, dried up about two hundred paces, so that the fish were left on the sand, a prey to the inhabitants of Puzzuoli. At last, on the 29th of the said month, about two hours in the night, the earth opened near the lake, and discovered a horrid mouth, from which were vomited furiously smoke, fire, stones, and mud composed of ashes; making at the time of its opening a noise like very loud thunder: the fire that issued from this mouth went towards the walls of the unfortunate city; the smoke was partly black and partly white; the black was darker than darkness itself, and the white was like the whitest cotton: these smokes rising in the air seemed as if they would touch the vault of heaven; the stones that followed were, by the devouring flames, converted to pumice, the size of which (of some I say?) were much larger than an ox.

"The flames went about as high as a cross-bow can carry, and then fell down, sometimes on the edge, and sometimes into the mouth itself. It is very true that many in going up could not be seen on account of the dark smoke; but when they returned from the smoky heat, they showed plainly where they had been by their strong smell of fetid sulphur, just like stones that have

* From the "Campi Phlegræi," p. 75.

been thrown out of a mortar, and have passed through the smoke of inflamed gunpowder. The mud was of the colour of ashes, and at first very liquid, then by degrees less so; and in such quantities that in less than twelve hours, with the help of the above-mentioned stones, a mountain was raised of a thousand paces in height. Not only Puzzuoli and the neighbouring country was full of this mud, but the city of Naples also, the beauty of whose palaces was, in a great measure, spoiled by it.

"The ashes were carried as far as Calabria by the force of the winds, burning up in their passage the grass and high trees, many of which were borne down by the weight of them. An infinity of birds also, and numberless animals of various kinds, covered with this sulphurous mud, gave themselves up a prey to man.

"Now, this eruption lasted two nights and two days without intermission, though it is true, not always with the same force, but more or less: when it was at its greatest height, even at Naples you heard a noise or thundering like heavy artillery when two armies are engaged. The third day the eruption ceased, so that the mountain made its appearance uncovered, to the no small astonishment of every one who saw it. On this day, when I went up with many people to the top of this mountain, I saw down into its mouth, which was a round concavity of about a quarter of a mile in circumference, in the middle of which the stones that had fallen were boiling up, just as in a great cauldron of water that boils on the fire.

"The fourth day it began to throw up again, and the seventh much more, but still with less violence than the first night; it was at this time that many people who were, unfortunately, on the mountain were either suddenly covered with ashes, smothered with smoke, or knocked down with stones, burnt by the flame, and left dead on the spot. The smoke continues to this day,* and you often see in the night-time fire in the midst of it.

* The cup or crater on the top of the new mountain is now (1776) covered with shrubs, but I discovered at the bottom of it in the year 1770, amidst the bushes, a small hole, which exhales a constant hot and damp vapour, just such as proceeds from boiling water, and with as little smell: the drops of this steam hang upon the neighbouring bushes.—*Sir W. Hamilton.*

Finally, to complete the history of this unforeseen event, in many parts of the new-made mountain, sulphur begins to be generated."

Giacomo di Toledo, towards the end of his dissertation, says that the Lake of Avernus had a communication with the sea before the time of the eruption.

III.

By FRANCESCO DEL NERO.*

A Letter to Niccolo del Benino on the Earthquake at Pozzuoli, by which the Monte Nuovo was formed in 1538.

I am not aware whether you have ever been at Pozzolo. Six bow-shots from the town, there commences a plain about half a mile broad, directly before Monte Barbaro, which enclosed a part of this bay; but now the plain extends over the whole of it, a circumstance which, although a natural event, nevertheless is very remarkable, and worthy of being accurately inquired into. Aristotle, in his 2° Meteor, mentions two similar events as worthy of record—the one in Pontus, the other in the island of Sagre.

On the 28th of September, at mid-day, the sea-bottom near Pozzolo became dry over an extent of 600 braccie (1,300 yards), so that the inhabitants of the town carried off waggon-loads of fish left on the dry land. About eight o'clock in the morning of the 29th, the earth sank down about two canne (13½ feet) in that part where there is now the volcanic orifice, and there issued

* From a communication by Leonard Horner in the *Quarterly Journal of the Geological Society*, vol. iii., part ii., page 19, and previously published in German in the *Neues Jahrbuch für Geologie*, of Leonhard and Brown, of 1846. The original MS., in Italian, was discovered in a volume in the library of the Marquis Capponi, but formerly belonged, Francesco Palermo says, to the family of Roffia di Samminiato.

forth a small stream of very cold water, as we were told by some persons we interrogated, but others stated that it was tepid, and somewhat sulphurous. As all the people whom we spoke to were persons worthy of credit, I am of opinion that they all spoke the truth, and that the water was at first cold and afterwards tepid. At noon on the same day, the earth began to swell up, so that the ground in the same place where it had sunk down 13½ feet, by eight o'clock, or thereabouts, was as high as Monte Ruosi—that is, it was as high as that hill is where the little tower stands upon it; and about this time fire issued forth and formed the great gulf with such a force, noise, and shining light, that I, who was standing in my garden, was seized with great terror. Forty minutes afterwards, although unwell, I got upon a neighbouring height, from which I saw all that took place, and, by my troth, it was a splendid fire, that threw up for a long time much earth and many stones. They fell back again all round the gulf, so that towards the sea they formed a heap in the form of a crossbow, the bow being a mile and a half, the arrow two-thirds of a mile in dimension. Towards Pozzolo, it has formed a hill nearly of the height of Monte Morello, and for a distance of seventy miles round, the earth and the trees are covered with ashes. On my own estate I have neither a leaf on the trees nor a blade of grass. In the neighbourhood of Pozzolo, to a distance of six miles, there is not a tree standing which has not its branches broken, and frequently it is not possible to say that there has been a tree on the spot. The ashes that fell here were also soft, sulphurous, and heavy. They not only threw down the trees, but an immense number of birds, hares, and smaller animals were killed. I was yesterday obliged to return by sea to Pozzolo, my companion being Messer Cacco de Loffredo, the agent of Messer Pavolo Antonio.

Many men were looking on, and with amazement. Nothing was to be seen there but the hill itself. When I say nothing, I mean in comparison with what took place the preceding night, when the earth swelled up—that is, at the time I came to the place. And as there was no one from Naples, and few capable of describing it who saw the fire on that night, there is no one but myself who can make a report upon it. Since the night when the

troops left the place, nothing remarkable has occurred, or that can in the least be compared with that which happened before. I will make the event clear to you by an example.

Imagine the fiery gulf to be the Castle of St. Angelo, filled with lighted rockets. There can be no doubt that these rockets, although they would shoot right up into the air, would, in coming down, change their direction, and in place of falling back into the castle from which they were sent up, would fall into the Tiber and on the neighbouring meadows. Imagine, further, that the cases of the rockets fell in such numbers into the Tiber as to fill up its channel, that they lay $27\frac{1}{2}$ feet thick, and that they fell in such quantities on the meadows as to form a hill, extending from Messer Bindo's vineyard as far as Monte Mori, and with a height little less than that of Santo Silvestro, near Tusculum; towards St. Peter's we shall suppose that few fell, because the wind blowing from the west carried them in another direction. Just so was it with the fiery gulf, from which there was shot up into the air, to a height which I estimate at a mile and a half, masses of earth and stones as large as an ox. They fell down near the gulf in a semicircle of from one to three bow-shots in diameter, and in this way they filled up this part of the sea, and formed the above-mentioned hill. When the earth and stones fell, they were quite dry. The same fire, however, threw out at the same time a light earth and smaller stones to a much greater height, and these fell down in a soft muddy state—an evident proof that they had reached the higher regions, and that the vapours, like other vapours which rise to the same height, were converted into water. This was the cause that the ashes fell in a softened state, mixed with a small quantity of water, although the sky was clear.

I could now state the natural causes of the drying up of the sea-bottom, and the mode by which that drying-up by means of the little stream, first of cold and afterwards of tepid water, was brought about; I could also state the causes of the sinking of the ground and the elevation of it that followed, and finally the causes of the outburst of the fire, and of the earthquakes which were felt here ten days before, and so frequent as ten in one hour, which unceasingly shook the earth at Pozzolo, but entirely ceased

both here and there as soon as the eruption took place. But as I know that Messer Simone Porzio, who possesses a thorough knowledge of the subject, has written to the Viceroy and to the highly distinguished Farnese, I will not seem to be decking myself with the merits of others. Pozzolo is quite deserted by the inhabitants, and you would not know the place of the sea here, for it would appear like a ploughed field, and it has a covering of what is here called *rapillo*, about half a palm thick (1½ inch), which is so light as to swim on water. But what is to me inconceivable is the mass of stones and ashes that was poured forth from this gulf; and when we take into account the quantity that must have fallen into the sea, and upon the newly formed hill, and think of the ashes which, as you know, were scattered in all directions, and are the remains of burnt materials, and if we imagine all these brought together in one place, what an immense mountain they would form! I spoke this morning with a man from Eboli, a town forty-five miles distant from the fire. He told me that the ashes had fallen in that place, that the fire had extended ten miles underground, and that this was the cause of the extraordinary quantity of earth that had been thrown into the air. Had this eruption not happened, the fire must have extended much further underground; and God grant that the vault may not spread out under Naples! Only yesterday, as we returned to Pozzolo by land, we saw two fire-gulfs just opened in the ground three miles from Naples. Many opinions have been expressed by very able men, and some think that Naples is in great danger. There have been some processions, and innumerable very deep wells have been sunk between Naples and Pozzolo, "as it were *to bleed* the fire." Viewed as an omen, the event is thought to forebode, as the rockets were driven from west to east, that the Emperor is going to attack the Turks.

IV.

By SIMONE PORZIO.*

De Conflagratione Agri Puteolani Simoni Portii Neapolitani Epistola

To the Most Illustrious Don Pedro de Toledo, Prince of Villafranca, Viceroy of the Kingdom of Naples, Generalissimo of the Army.

THERE are many things which, although proceeding from natural causes, nevertheless because they occur rarely, appear to be portentous marvels, and especially so to those who only hear of the events without having actually witnessed the phenomena. Wherefore, since nothing untrue may be related to you concerning that which not long ago (A.D. 1538) happened in the plain of Pozzuoli, and feeling under an obligation to state to you my

* This letter of the eminent Neapolitan "philosofo" of the sixteenth century, in its first printed form, is exceedingly rare, but a copy is preserved in the Biblioteca Nazionale di Napoli. The epistle was, however, with thirty-four corrections by its author, included in his works (Simoni Portii Opera, Flor. 1548-1553), and so published in the year 1551.

An edition, also in Latin, was published in Naples in 1817. [I Tre Rarissimi Opuscoli di Simone Porzio, di Girolano Borgia, e di Marcantonio delli Falconi, scritti in occasione della Celebre Eruzione avvenuta in Pozzuoli nell'anno 1538, colle Memorie Storiche de' suddetti autore, Raccotte da Lorenzo Giustiniani, Bibliotecario della Real Biblioteca Borbonica, e Regio Revisore. Napoli, MDCCCXVII.]

The letter was translated into Italian by Giuseppe Amanduni, and published in Naples in 1878, with some interesting prefatory remarks. [Dell' Incendio dell' Agro Puteolano Epistola di Simone Porzio al Vicerè d. Pietro di Toledo, Traduzione critica di Giuseppe Amenduni, Napoli, Tipografia dell' Accademia Reale delle Scienza, Diretta da Michele de Rubertis, 1878.]

Simone Porzio's letter is now for the first time printed in English. To make this version reliable, a translation of Amanduni's edition by myself has been compared with two independent translations by accomplished Latin scholars, the Rev. F. A. Walker, D.D., and Prof. Langhorne Orchard, M.A., who very kindly at my request separately translated the edition of 1551, and improvements so suggested have been adopted.—J. L. L.

experiences, and especially those which relate to our studies, I have resolved to narrate with brevity the whole matter, and to state to you its causes, as is properly the part of a philosopher, under the impression that I shall not be doing what is distasteful to you.

You indeed witnessed the conflagration, and had in your view the whole plain of Pozzuoli. This district is near the sea, and abounds with warm waters and sulphurous mud, and has mountains on its northern and on its southern side, which extend quite down to the sea, and which have at their termination many large caverns in which there is a great force of heat. The region was disturbed for about two years by violent earthquakes, so that no house remained uninjured, and there was no building which was not threatened with sure and speedy destruction. And truly, on the 26th and 27th of September, the earth was continually, both by day and by night, thoroughly agitated; the sea receded for about 200 paces, and on its bed not only did the inhabitants take an immense quantity of fish, but springs of fresh-water were also seen to gush forth. At length, on the 28th, the large tract of land which lay between the foot of the mountain, called by the inhabitants of the vicinity Barbaro, and the sea in the neighbourhood of Avernus, was seen to rise and take the form of a newly produced mountain. And on the same day, at the second hour of the night, this mound of earth opened like a mouth, with a great roaring, vomiting much fire and pumice and stones, with such a great abundance of offensive ashes as covered the buildings still remaining standing in Pozzuoli, quite covering over the herbage, breaking the trees, and reducing to ashes the hanging vintage as far as the sixth milestone, and killing birds and some quadrupeds, while the inhabitants of Pozzuoli, flying amidst the gloom along with their children and wives, and made their way to Naples with groans, and cries and tears.

The ashes, by the force of the explosion, were ejected to a distance of about sixty thousand paces; and what may seem more marvellous, those that fell near the centre of disturbance were dry, while those falling at a distance were muddy and wet. But what was most wonderful of all, the hill at the centre of disturbance was seen to have been piled up in a single night with

pumice and cinders to a height of more than a thousand paces; in which indeed were many vents, of which now only two remain, one near the shore going on to Avernus, the other in the middle of the mount itself. As to Avernus, a large portion is covered with ashes. Those baths, celebrated through so many centuries, and which used to give health to so many invalids, lie buried in ashes. And this conflagration continues, though with some interruptions, to this day, of which, in accordance with my promise, I will endeavour to explain the proper natural causes.

Some things that happen in nature rarely do not proceed from a single cause, since some are without a definite origin, as those that arise haphazard and by chance; but there are others which, although of rare occurrence, are not without a particular cause. Of this kind are eclipses, fiery exhalations, and earthquakes. But this eruption of which we are treating having occurred after violent earthquakes, something ought to be first said respecting these earthquakes, after which the conclusions concerning the opening of the earth may be more conveniently explained.

The sun acting on the damp earth draws out a certain sort of fume which, if very dense and moist, is called vapour, that produces watery things, as clouds, the rains, and perennial waters; but if drier or that which Aristotle called exhalations, it produces things which are dry and arid. This fume generated in the caves and caverns of the earth is either all discharged, or all confined, or it is partly emitted and partly retained. If it all escapes it impels the air with its force and produces winds; if it is altogether retained, either by the passages and fissures of the earth, or because of the solidity of the dry land, or from frequent rains which obstruct the earth's pores, or from the neighbouring sea, which as much by its cold as by its waves drives it back again into the interior of the earth, then being fiery and restrained by force, and seeking a vent with swiftest motion, it shakes the earth and causes violent earthquakes. But if part only escapes and part is retained under the earth, there are less violent earthquakes, since the force is diminished; the portion which is released moves the air, and that which is retained agitates the earth.

Neither should those higher causes be omitted which Astrologers adduce, namely, the conjunction of stars and the eclipses

of the sun and moon. All these have occurred during these times of which we speak. In the first place, there was the conjunction of Mars with Saturn in Virgo, in the last solstice, which usually causes exhalations and excites earthquakes. There were, moreover, not only in this, but also in the previous year an eclipse of the moon and appearances of comets.

There are also to be taken into consideration the seasons most favourable for the production of earthquakes, and which are the spring and the autumn, in which occur an increase of moisture and heat, whence the sun generates vapours and exhalations the production of which is impeded in the winter by much cold, and in the summer by much heat.

Such are some of the causes that are considered by philosophers capable of producing earthquakes and determining the seasons of their occurrence. To them should be added the fact that during last summer there were copious rains, giving the season more the character of autumn than of summer ; whence it is not to be wondered at that our district has suffered from frequent earthquakes, since the season furnished more plentiful and suitable material wherewith the sun could produce exhalations.

The dawn is, moreover, the time favourable for earthquakes because the sun returning to us drives away the cold from the earth, and this obstructs the outlets of the exhalations, which then moving with great force and rapidity, shake the earth. But still more favourable is noonday, when the sun dissipates the upper exhalations, and draws up those below which shake the earth ; and thus the surface may be undisturbed, while the interior is moved.

But the locality that is especially liable to be shaken by earthquakes is one that has the following natural conditions : proximity to the sea, and a soil, like a sponge, that has many openings and caverns ; and these conditions characterising the Plain of Pozzuoli, frequent earthquakes are here occasioned. Numerous exhalations are therefore gathered together in the deep places of the earth, and this accumulation seeking an outlet, approaches the place whence it can escape, and disturbs the more those places adjoining the vent. This was the cause of the earthquakes being continuous in those days. Finally, these

exhalations with the most rapid motion inflamed the bitumenous and fire-affected matter in the caverns of the earth, which, with a great explosion, was completely ejected. These are, therefore, the causes which have produced the opening. But many phenomena having preceded the formation of this gulf and opening of the earth, and accompanied it, it will not be foreign to my purpose to particularly examine into their causes.

Firstly, the sea retreated, truly, from no other reason than because the exhalations, seeking a vent, rarified the ground, which, as though thirsty, absorbed the water through its pores, whence it happened that the part first washed by the sea became dry, and the shore was raised in height by the ashes and lapilli.

Again, there had been previously a spring of cold water. This was because the water was compressed by the exhalations rising out of the earth, so poured out more abundantly, from the earth yielding to the outrush of the water, and the water falling to the bottom was quickly raised again by the force of the exhalations seeking escape.

Some persons are in doubt as to whether the fire pre-existed in the bitumen, or whether it was not rather kindled by the action of the exhalations. Our reply is that the matters were previously burning, since the waters that were forced from them and issued at the surface were hot, but that the fire was much increased from the impetus and the force of the ejections making their escape.

Others wonder why it is that smoke is not constantly issuing, and the roaring is not constantly heard, since during certain intervals of time all seems to be quiet. The cause of this is that at first the mouth of the opening was small, and the flames issuing from the deep interior of the earth, being ready and near the mouth of the gulf, were ejected with great roaring, then afterwards, while the other part of the exhalations was moving from the depths of the earth towards the mouth of the gulf, the noise could not be heard by persons at a distance. It is true that the ashes, after having ascended, fell drier in neighbouring places, and were moist at a distance. Of this phenomenon I believe the cause to be that the ashes ascending are made drier by the burning heat,

but when not being able to fall for a long distance, not before reaching the middle region of the atmosphere, they are there made denser and more humid, and then they fall.

But the less educated inquire how long this eruption will continue. To such persons my reply is that I am not able to tell, nor can it be told until the matter on which the fire is fed is weighed. Certainly, whoever compares the fire of Vesuvius with this of Pozzuoli will easily understand that this one will not have a less duration, since it is a large area, indeed the whole district of Pozzuoli, full of sulphurous bitumen, the material specially adapted for fire, and such as does not quickly become exhausted.

Some anxiously inquire what these things prognosticate. I say truly, along with the Peripatetics, that there is no certainty in any foreboding, although Cicero gives great heed to, and also draws much from, portents. Nevertheless I affirm what I have contended elsewhere, that nothing certain is to be expected from these events except dryness, usually followed by dearth, and also pestilence, from learning what happened many centuries ago. The astrologers say that intestine wars are to follow, since even as bodies burn from former defilements, so is the soul of man more subject to anger. But all these things are consequent upon dryness, as has been shown in my books on Meteorology. If there are those who think differently, I will not refuse at any time to be taught by their arguments.

Aristotle has left it on record that similar things happened in Heraclea, a city of Pontus, and in an island sacred to Æolus. In the second year of the reign of the Emperor Titus, Mount Vesuvius from another vortex ejected a great quantity of fire. Similarly in the reigns of the Emperors Cæsar Augustus, Titus, and Antoninus Quartus, and Diocletian, and also in the consulates of L. Marzio and Sextus Julius, it has been recorded that such a gulf opened and such conflagrations occurred in the Island of Ischia, the place where so many fires were burning in the year of our salvation 1300, that almost the whole island was on fire. The cause of this will, however, be explained on another occasion.

What I have here stated, I have thought it my duty to write, O my Mæcenas [patron], lest the soothsayers and

interpreters of dreams and the common astrologers explain otherwise those phenomena that take place under the guidance of Nature.

CATALOGUE OF RECORDED ERUPTIONS.

From the renewal of the activity of Vesuvius in A.D. 79 to the present time, upwards of eighty eruptions have been recorded, of which thirteen have been accounted *great* or *paroxysmal* eruptions.

The following table gives the dates of the various historic eruptions. But the word "eruption" requires explanation, since it is now seen to have rather a relative than a specific meaning. Judging from the observations of modern times, as previously stated, the volcano has often, and sometimes for long periods, been in a state of little developed eruption. Who shall say that this has not been the case in long-back times, when there were no such careful recorders as recent days have furnished?

Eruptions of Mount Vesuvius.

A.D.	
*79.	Pompeii, Herculaneum, and Stabia destroyed.
*203.	
*472.	
*512.	
*685.	
983.	
*993.	
*1036.	First recorded fluid lava.
1049.	
*1138 or 9.	6 Kal. Jan.
1306.	
1500.	
1568.	
*1631.	Great flow of lava—18,000 persons perished.
†1649.	
1660.	
1676.	Perpendicular column of lava.
1682.	
1685.	
1689.	
1694.	March 12, with feeble recurrences till
1698.	
1701.	
1704.	May 20, with feeble recurrences till August, 1707.
1707.	
1712.	With recurrences in 1713, 1714, 1716.
1717 and 1718.	
1720.	With recurrences in 1723, 1724, 1725.

† A MS. account of this eruption has recently been discovered, and is printed in "Lo Spettatore"

A.D.
1726. July 26.
1730. February 27.
1733.
1737. May 14, great flow of lava.
1751. October 25.
1754. December 2.
1759.
*1760. December 23, new crater on mountain side opened.
1766. March 25.
1767. October 23.
1771.
1776. September 22.
1779. August 3, perpendicular column of lava.
1783. August 18.
1784. October 12 and December.
1786. October 31.
1787. December 21.
1788. July 19.
1790. September 6.
*1794. June 15, great flow of lava, Torre del Greco suffered great injury.
1804. August 12 and November 22.
1805. July.
1806. May.

A.D.
1810. December 10.
1812.
1813. May to December.
1816.
1817. December 22 to 26.
1818.
1819. April 17.
1819. November 25.
1820.
*1822. 800 feet of the cone blown away; great discharge of ash and vapour.
1828.
1831. August 18.
1833.
1834. August.
1838. Minor eruptions of scoria.
1845. Ditto.
1850.
1854.
1855. Lava very fluid.
1858.
1861.
1868. Long continued.
*1872. Exterior eruptions.
1881.

THE STRATA UNDERLYING VESUVIUS.

Artesian Well Section (Pozzo dell' Arenaccia).

The construction of an artesian well at Arenaccia, near the Ponte della Maddalena, on the Vesuvian side of Naples, in the year 1880, has furnished a very interesting section, showing the precise character of the strata underlying the plain from which Vesuvius rises, to a depth of about 400 feet below the level of the sea. The section is compared with that furnished by the artesian well of the Royal Palace at Naples, with detailed description and analyses by Dr. Paride Palmieri, in "Lo Spettatore del

Vesuvio," from which the following particulars of the beds at the well of Arenaccia have been obtained.

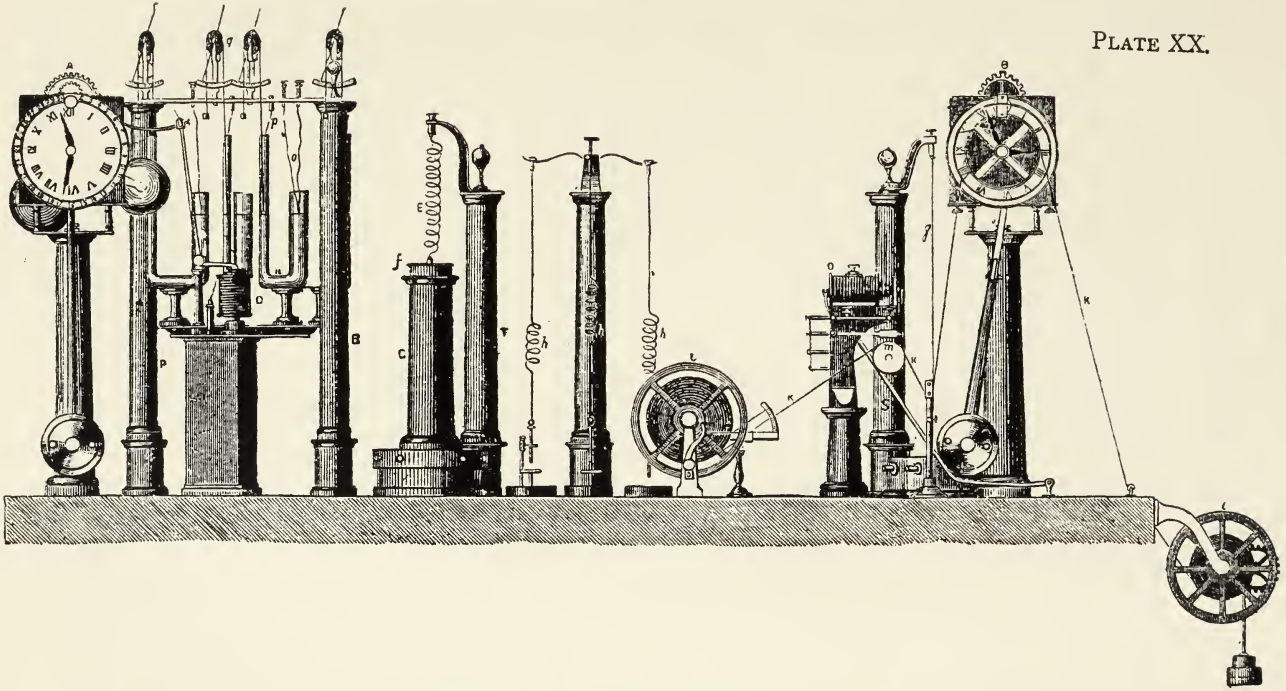
IL POZZO ARTESIANO DELL' ARENACCIA.

Below sea level. Feet.	Ins.	Character of Beds.	Thickness of Beds. Feet.	Ins.
		Arable soil	8	4
		Sea level.		
		Sand	40	10
40	10	... ... Pozzuolana, lapilli	16	5
57	3	... ... Volcanic "delsito"	16	5
73	8	... ... Sand	4	11
78	7	... ... Coarse sand	6	7
85	2	... ... Stones, lava	9	10
95	0	... ... „ „ larger	7	6
102	6	... ... Pozzuolana	6	7
109	1	... ... Stones, tufa	11	6
120	7	... ... Sand with water	1	1
121	8	... ... Tufa, yellow	16	5
138	1	... ... Tufa, greenish	55	9
193	10	... ... Tufa, vesicular	32	9
226	7	... ... Marly clay	19	8
246	3	... ... Stones, lava	2	11
249	2	... ... Ashes	13	5
262	7	... ... Clay	9	10
272	5	... ... Stones, lava, lapilli	52	6
324	11	... ... Sand	36	1
361	0	... ... Pumice	3	3
364	3	... ... Sand	16	5
380	8	... ... Tufa	3	3
383	11	... ... Gravel (water)	16	5
400	4			

PROFESSOR PALMIERI'S SEISMOGRAPH.

THE author is greatly indebted to the Proprietors of the *Engineer* for permission to reproduce their illustration of Professor Palmieri's Vesuvian Seismograph, which, together with

PLATE XX.



PROFESSOR PALMIERI'S SEISMOGRAPH.

the following description, appeared in the *Engineer* of June 7th, 1872 :—*

E is a helix of brass wire (gauge about one millimetre); the helix consists of fourteen or fifteen turns, and has a diameter of from twenty to twenty-five millimetres; it hangs from a fine metal spring, and can be raised or lowered by a thumb-screw. From the lower end of the helix hangs a copper cone with a platinum point; the latter is kept close to the surface of mercury in the iron basin, *f*, which rests on an insulating column of wood or marble, G. The distance of the point from the surface of the mercury remains constant, as the metal pillar, T, is of such a length that its expansion or contraction by change of temperature compensates that of the helix; the latter is in connection (by T) with one pole of a Daniell's battery of two cells, and the basin, *f*, is connected with the other pole. Any vertical movement, however slight, makes the platinum point dip into the mercury, and thus completes the circuit. In this circuit are included two electro-magnets, C and D; these, during the circulation of a current, attract their armatures, which are connected with levers. The action of C's lever is to stop the clock, A, which thus records to a half-second the time of the occurrence of the shock, at the same instant that the clock strikes an alarm bell, which attracts the attention of an observer. The lever attached to the armature of D, at the first instant of the current frees the pendulum of the clock, B, which was before kept from swinging, in a position out of the vertical; the clock then acts as a time-piece, and its motion unrolls a band of paper, *k k k*, at a rate of three metres an hour. At the same time the armature of D, while attracted, presses a pencil-point against the band of paper which passes over the roller, *m*, marking on it, while the earthquake lasts, a series of points or strokes which occupy a length of paper corresponding to its duration, and which record the work of the shock. After it is over, the paper continues to unroll from the drum, *i*, and passing round the clock, rolls on to the drum, *l*. If a fresh shock occur the pencil indicates it, as before, on the

* The description was originally contained in Mr. Mallet's "Notes" to his translation of Palmieri's "Eruption of Vesuvius in 1872," and the illustration is from Plate VIII. of that volume.

paper, and the length of blank paper between the two sets of marks is a measure of the interval of time between the shocks. By way of additional check, several helices, *h h h*, are hung from a stand, with small permanent magnets suspended from their ends; below and close to these latter are small basins, holding iron filings; into these the points of the magnets dip, when their helices oscillate vertically, and some filings remain sticking to the magnets as a record of the shock. One of the magnets has a shoulder on it which moves an index hand along a graduated arc, thus again registering the amount of the vertical movement. Such are the arrangements intended for the record of the undulatory or horizontal elements of the wave of shock.

The following are the arrangements proposed for recording the horizontal motions: On the stand, to the right of the clock, A, are set four U-shaped glass tubes, open at their ends. One of each pair of vertical branches must have a diameter at least double that of the other. These pairs, with their supporting columns, are shown in plan, where one pair lies N. and S., another E. and W., a third N.E. and S.W., and the other N.W. and S.E. It will be observed that metallic bars pass from the pillar, P, over the ends of all the long branches, and similar bars pass from R, over the ends of the short branches; the pillars themselves, as in the case of the other instruments, are each connected with one pole of a Daniell's battery, the connections including the electro-magnets, C and D. The description of one U tube, *n*, will apply to all the others; *n* is partly filled with mercury, and an iron or platinum wire, *o*, suspended from the bar above the short branch, dips into the mercury therein, while another platinum wire hung from the bar over the mouth of the longer branch has its end very close to the surface of the mercury in that branch. Any shock which is not perpendicular in direction to the plane of the branches of the U will cause the mercury to oscillate in the tubes, and more sensibly in that with the smaller diameter; when it rises up in the latter, so as to touch the platinum point, the connection between P and R is made and the circuit completed, starting the action of the electro-magnets C and D, which record the shock, as already described. By having the planes of the tubes set in the different azimuths,

already mentioned, one or more of the pairs is sure to be acted upon, and by observing in which the oscillation takes place the direction of the shock is supposed to be ascertained. Besides this, each long branch of the U, viz., that of the smaller diameter, has a small ivory pulley, *q*, fixed above it, over which passes a single fibre of silk, with an iron float at one end, resting on the surface of the mercury; at the other end of the fibre hangs a counterpoise; fixed to the pulley is a fine index hand, capable of moving along a graduated arc. When the shock takes place the mercury, rising in the long branch, raises the float on its surface, the silk fibre at the same time makes the pulley revolve with its index hand, which afterwards remains stationary, as the counterpoise prevents the float from sinking again with the mercury. The reading on the graduated arc is thus a measure of the movements produced in the instrument by the horizontal element of the shock, and is supposed to measure that shock. It is assumed that in all these instruments shocks, however small, can be recorded with certainty by adjusting the distance between the platinum points and the mercury.

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